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July 8, 2016

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Asia and Pacific Department

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THE SINGAPORE SMALL MONETARY POLICY MODEL (SGPMOD)[1]

This paper develops a new calibrated model of the Singapore economy, the Singapore Global Policy MODel (SGPMOD) and uses it to conduct a variety of policy experiments focused on the conduct of monetary policy. SGPMOD shares its theoretical underpinnings with the International Monetary Fund's 7-region Global Projection Model (GPM-7). It also is similar to the Monetary Authority of Singapore (MAS) Small Model of Singapore (SMS), itself an offshoot of the IMF's GPM. SGPMOD is used to illustrate the role of MAS monetary policy responses to a variety of domestic and external shocks, including (1) a downward revision of Singapore's expected growth path; (2) a downward revision of China's expected growth path; and (3) the effects of Brexit. In all cases, expansionary MAS monetary policy plays a positive role in ameliorating the effects of negative shocks to Singapore's economy. However, in the case of permanent shocks, as expected, the MAS cannot prevent the long-term fall in output; it can only mitigate the short-term effects.

A. Introduction

1. The purpose of this paper is to contribute to the analytical literature on Singapore's monetary policy. It develops a new, calibrated forward-looking gap model of the Singapore economy, SGPMOD, that contains explicit links to developments in the rest of the world (USA and China), and uses it to conduct a variety of policy experiments. The model extends recent analytical literature on Singapore's monetary policy, including contributions by the MAS, which provides ample support to the proposition that MAS pursues a domestic price stability objective using a unique exchange rate-based reaction function (Parrado, 2004; McCallum, 2006; Khor and Robinson, 2008; IMF, 2015; and MAS, 2016).

2. Viewed in this light, the policy framework that the MAS has operated since the 1980s is akin to an inflation targeting (IT) regime with the exchange rate rather than the interest rate as the policy instrument—specifically Singapore's nominal effective exchange rate (NEER) against a trade-weighted basket of currencies. The MAS adjusts the NEER path within a band to ensure that it is consistent with development of inflation in the year ahead, taking into account the effect of output growth on prices. The choice of the exchange rate as the instrument for price stability is a natural one considering Singapore's small, extremely open economy and strict adherence to capital mobility, which makes it difficult to control domestic interest rates. While the inflation target pursued by the MAS and the parameters of the BBC framework are not disclosed, monetary policy is communicated by the MAS to the public, the goals and conduct of monetary policy are clearly communicated in broad terms, and explained at regular intervals.

3. The principal innovations in SGPMOD are, first, that it is a multi-region model, including both the United States and China, and a small reduced-form block for the other regions. Second, it tracks all the components of the nominal effective exchange rate (NEER), although its interest rates

[1] Prepared by Dirk Muir (RES).

come from uncovered interest parity vis-à-vis only the United States, reflecting Singapore's role as a global financial center linked to the United States. Third, based on calibration from other, larger structural models at the IMF, SGPMOD attempts to link shocks to trends in the long term the movements in gap variables in the short term.

4. This paper presents SGPMOD, considers its properties, and discusses the MAS monetary policy responses using the estimated MAS rule. Section B presents the model in detail. Section C examines the monetary policy transmission mechanism, using a fall in domestic demand to illustrate it. Section D uses the estimated monetary policy rule to discuss the response to shocks related to Singapore's growth path, two variants on China's future growth prospects, and the effects of Brexit. Sections C and D also discuss how policy would actually be implemented in the MAS' Basket-Band-Crawl framework.

B. The Structure of SGPMOD

5. **MAS' Policy Framework.** This section develops the constituent parts of the SGPMOD. The MAS uses an IT regime using a target for the NEER. This is officially known as the Basket-Band-Crawl framework, or BBC (see MAS, 2001 and Khor and others, 2004). The MAS announces twice a year (in April and in October) its intentions for the target NEER. It communicates the changes in the BBC in general terms, not specific numbers. It discusses its three components:

- ***Basket*** = the composition of currencies used in the target NEER to guide monetary policy. The basket is composed of the currencies of its major trading partners, weighted by their share in trade—in particular, Malaysia, Indonesia, China, the United States, and the euro area, along with other countries, including most countries in South East Asia.

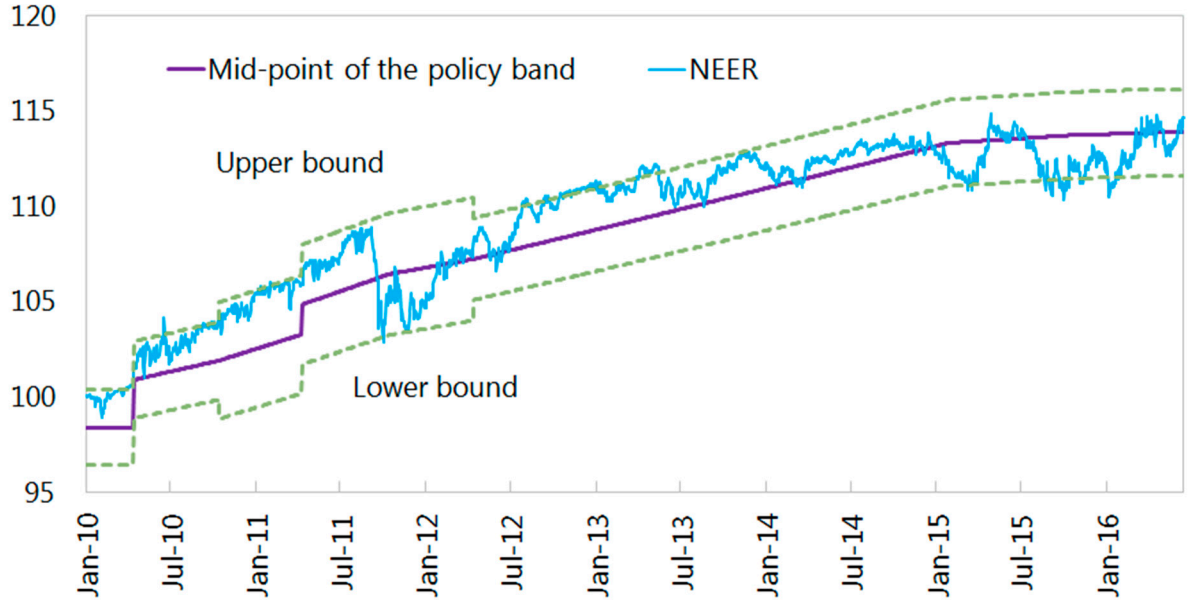
- ***Band*** = the permitted percentage variation around the MAS' target NEER.

- ***Crawl*** = the permitted quarterly change in the MAS' target NEER. It is usually a rate of appreciation, although sometimes it is set at zero. If the target NEER is perceived to be too high, instead of depreciating the rate of crawl, the MAS will simply announce that it has enacted a once-off, immediate, depreciation in the level of the target to ***re-center*** it.

Notional Path of the Target NEER

6. **Estimated NEER Path.** Even though the MAS' target NEER path is not officially announced, market participants can (and do) deduce it in a timely fashion from the MAS' announcements and explanations, coupled with market behavior, particularly any perceived exchange rate interventions on part of the MAS. Figure 1 presents staff's estimates of the MAS' target NEER, in line with most market participants, since the start of 2010.

Figure 1. Staff Estimate of the MAS' NEER Path and its Bands

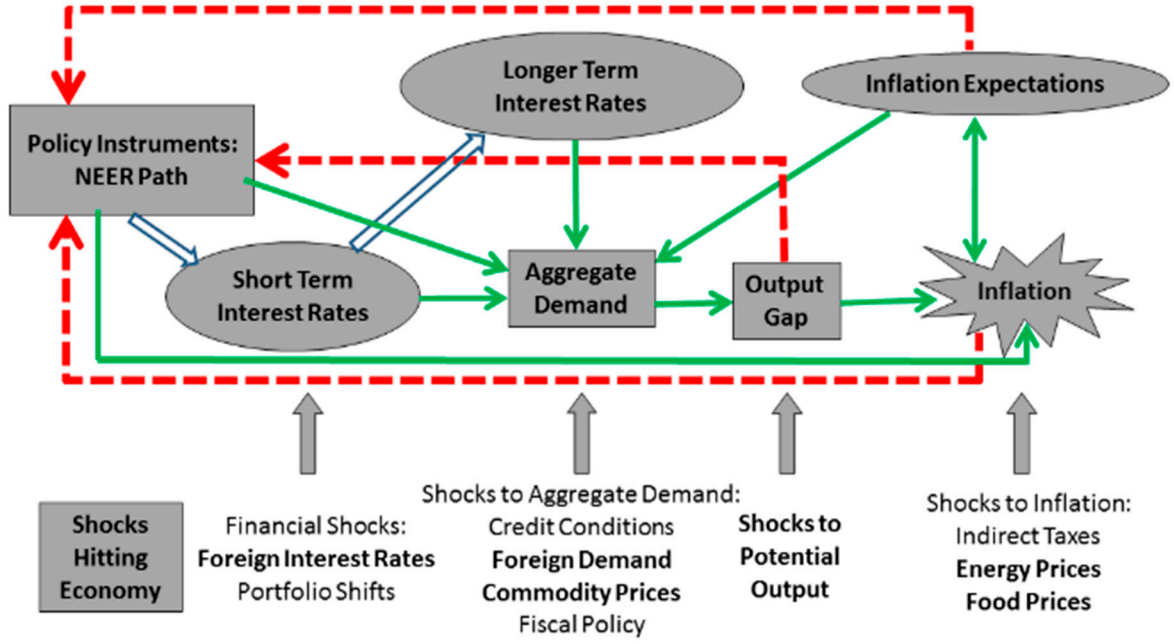


Sources: IMF's INS, MAS weekly NEER; and IMF staff calculations.

NEER-Based Model for an IT Regime

7. Model in Schematic Form. In order to better understand the role of monetary policy in the Singaporean economy, we consider its role in the context of a small, simple model (Figure 2). The MAS' monetary policy instrument, the NEER, is the central nexus of the economy, being determined by its most important elements—real GDP via the output gap, inflation, and expected inflation. Then, in turn, it directly affects aggregate demand, inflation and interest rates.

Figure 2. NEER-Based Model for an IT Regime



Source: IMF staff.

8. Model Equations. At its heart, SGPMOD is a quarterly canonical gap model, with the 5 standard building blocks for each region:

- I-S curve (the output gap, defining aggregate demand);
- Okun's law (the unemployment rate);
- Phillips' curve (core CPI inflation, driving aggregate supply);
- Uncovered interest parity (the short-term interest rate); and
- Monetary policy rule (the NEER).

9. Structural Interpretations. While all equations are reduced forms, they each have structural interpretations. They interact with one another and allow the computation of a general equilibrium in the economy. Expectations in the model are rational, which has important implications for the behavior of both inflation and the exchange rate. While the model is simple, it is well suited for its main purpose, the study of the conduct of monetary policy in Singapore in the context of an IT framework.

10. Presenting the Model. We look at these key equations for the domestic economy, along with the monetary policy rule, followed by the associated trend variables. We then look closely at the construction of the different exchange rate measures, and other less important Singaporean variables. Then we turn to the rest of the world, which has the same country composition as found in GPM-7 (Blagrave and others, 2013). As we did for Singapore, we explore the complete models for

the U.S. and China blocks, along with an overview of the equations used to summarize commodities and the other regional blocks.

11. Notation. In order to be able to understand how the equations are written, please keep the following in mind, using real GDP as an example. The level of real GDP is represented in terms of natural logarithms, as Y_t, while potential output (which is the natural logarithm of trend real GDP) is represented as $\overline{Y}_t$. Finally, the output gap, the gap between real GDP and potential output, is specified as y_t, and can be interpreted as a percent deviation of output from potential. Also, please keep in mind that for any exchange rate, an increase in the variable is an appreciation.

Singapore—The Domestic Block

12. Summary. This subsection considers the five key equations for the Singapore block, along with any other equations from the rest of the world that help determine features of the Singaporean economy.

Aggregate Demand (I-S curve)

13. Defining the I-S Curve. The I-S curve relates domestic aggregate demand to domestic real interest rate and real exchange rate gaps and the output gap in the rest of the world.

$$y_t = b_1 y_{t+1} + b_2 y_{t-1} + b_3 rr_t^{avg} - b_4 reer_t + b_5 y_t^{ROW} + y_t^{shk}$$

Where *y* is the output gap, rr is the real expected short-term interest rate gap (in this case, average of *t* to *t+3*); $reer$ is the REER gap; and y^{ROW} is the foreign output gap (all other countries in aggregate).

14. Important Properties. Note that the output gap has both inertia in its development over time (the coefficient b_2) and dependence on its expected level next quarter (the coefficient b_1). However, for Singapore, the output gap is strongly influenced by the contemporaneous movement in the foreign output gap (dominated by the rest of emerging Asia, China and the United States, in that order; the coefficient b_5) and its negative correlation with the gap of the REER (the coefficient b_4) from its trend level.

Okun's Law

15. Defining Okun's Law. There is a standard Okun's Law relationship, with a strong negative correlation between the current output gap and the unemployment rate gap:

$$unr_t = c_1 unr_{t-1} + c_2 y_t + unr_t^{shk}$$

where unr is unemployment rate gap and *y* is the output gap, as before. From this we can derive the level of the unemployment rate, UNR,

$$UNR_t = NAIRU_t + unr_t$$

where *NAIRU* is the non-accelerating inflation rate of unemployment, the trend unemployment rate.

Phillips' Curve and Inflation

16. Defining the Phillips' Curve. The Phillips' curve is the equation for Singaporean core inflation as defined by the MAS, discussed further below. It acts as the aggregate supply curve for SGPMOD:

$$\pi_t = a_1\pi_{t+4} + (1-a_1)\pi_{t-1} + a_2\Delta reer_{t-1} + (a_3\Delta qoil_t + \Delta z_t) + (a_4\Delta qfood_t + \Delta z_t) + a_5\pi_t^{acc} + a_6 y_t + \pi_t^{shk}$$

where π is the MAS measure of year-on-year core CPI inflation; $\Delta reer$ is the quarter-on-quarter change in the REER gap; $\Delta qoil + \Delta z$ is the quarter-on-quarter change in real price of oil gap in SGD terms; $\Delta qfood + \Delta z$ is the quarter-on-quarter change in real price of food gap in SGD terms; π^{acc} is year-on-year inflation in the components for private road transport and household accommodation; and y is the output gap.

17. Pass-Through Effects. In addition, the weights on $\Delta qoil$ and π^{acc} capture the second-round pass-through effects of volatile headline CPI components into core inflation.

18. Relationship of Headline and Core Inflation. Core inflation is generally defined as CPI inflation, excluding the most volatile components, in order to capture the underlying trends in inflation which should be dealt with by monetary policy. For example, many countries exclude the effect of food and oil prices, which are very volatile in the short term, but do not lead to a direct sustained rate of change in the price level. Similarly, the United Kingdom excludes mortgage interest payments. In the case of Singapore, the MAS defines inflation as CPI inflation less private road transport prices (equals 11.5 percentage points of the headline CPI basket) and less accommodation prices (equals 22.9 percentage points of the headline CPI basket). These excluded components are considered to not be reflective of price trends, as they are largely driven by administrative measures. Note that the MAS still includes food in the basket, since although it is volatile, it is almost entirely imported, and a large part of the CPI basket—almost 27 percent. Moreover, because MAS' conduct of monetary policy affects the exchange rate directly (explored more below), this portion of CPI, heavily affected by the exchange rate, is a key determinant in the MAS' choices (Zong Yao and others, 2011). SGPMOD uses the MAS' measure of core inflation, but with a re-arranged division of its components, such that headline inflation can be represented as:

$$\pi_t^h = (1 - c_1 - c_2)\pi_t + c_1\pi_t^{acc} + c_2\pi_t^{oil}$$

where π^h is headline inflation, π^{oil} is domestic oil price inflation (and the weight c_2 is 6.5 percentage points, the oil share of private road transport prices), and π^{acc} is inflation in accommodation, and the non-oil portion of private road transport (with the weight c_1 of 27.9 percentage points).

19. Defining the Price Levels. From the three measure of inflation, we can derive their respective price levels:

$$\pi_t^h = CPI_t^h - CPI_{t-1}^h$$
$$\pi_t^{acc} = CPI_t^{acc} - CPI_{t-1}^{acc}$$
$$\pi_t^{oil} = POIL_t - POIL_{t-1}$$

Uncovered Interest Parity

20. Defining UIP. For Singapore, the risk-adjusted uncovered interest parity condition (UIP) defines the short-term interest rate relative to the short-term interest rate in the United States.

$$RS_t = RS_t^{US} + PREM_t - 4(S_{t+1} - S_t) + RS_t^{shk}$$

where *RS* is the nominal short-term interest rate; RS^{US} is the U.S. nominal short-term interest rate; S is the nominal bilateral US$ exchange rate; and $PREM$ is the country risk premium (with both permanent and transitory components).

21. The Role of the UIP Condition in Singapore. In many countries, UIP defines the nominal bilateral US$ exchange rate in the short- to medium-term, as the domestic short-term interest rate is determined by a monetary policy reaction function. However, in the case of Singapore, it is the monetary policy reaction function that indirectly determines *S* (see the next subsection), and the UIP condition, as a proxy for market conditions, imposes the level of Singapore's short-term interest rate.

Singapore—The Monetary Policy Rule

22. Summary. The monetary policy rule is SGPMOD's central equation for Singapore. Singapore is unique in that it uses a NEER-based reaction functions for its IT regime, instead of the standard interest rate reaction function. First, we discuss its specification, and then its estimation.

23. Defining the Reaction Function. The MAS does not explicitly state its monetary policy rule, but econometric work provides us a guide, and allows for this equation to mimic the BBC framework. Following in the footsteps of Parrado (2004) and McCallum (2006), it looks much like a standard interest rate reaction function, using the deviation of core CPI inflation from its target level, and the output gap.

$$\Delta NEER_t^{POL} = g_1 \Delta NEER_{t-1}^{POL} + (1 - g_1)[\Delta\overline{NEER}_t + g_2(\pi_{t+3}^e - \pi_t^{TAR}) + g_3\overline{y}_t + g_4\left(RS_t^{US} - RS_t^{US,neut}\right)] + \Delta NEER_t^{shk}$$

where $\Delta NEER^{POL}$ is the annualized quarter-on-quarter change in the MAS' target NEER; $\Delta\overline{NEER}$ is the annualized quarter-on-quarter change in the trend NEER; $\pi_{t+3}^e - \pi^{TAR}$ is the three-quarter-ahead expected MAS core inflation deviation from target; and RS^{US}— $RS^{US,neut}$ is the nominal U.S. short-term interest rate gap. The growth rate of the target NEER then implies a path for its level:

$$NEER_t^{POL} = NEER_{t-1}^{POL} + ¼\Delta NEER_t^{POL}$$

24. Relationship Between the Target and Actual NEERs. Given the MAS' target NEER and its band, it insures that the outcome for the NEER respects:

$$NEER_t = NEER_t^{POL} + NEER_t^{trans,shk}$$

where $NEER^{trans,shk}$, the transitory shock to the NEER, is the current wedge between the MAS' target and the market outcome for the NEER. If, in practice, the transitory shock does not return to zero, the MAS can always re-center its policy choice for the NEER.

Estimates for the Policy Rule

25. Background and Outcomes. We have estimated the NEER reaction function on Singapore data from 1992 to 2015. It is based on the work of Sheridan and Nadeem (2013) and Arbatli (2015). Their work tested a variety of specifications, based not only on inflation and the output gap, but also unit labor costs. In this work, we left aside the versions of the policy rule using unit labor costs, since SGPMOD is too simple in its structure to exploit that econometric specification. The two best specifications are based on an output gap measure from Gupta (2015), and an inflation gap based on an inflation target of 2 percent, along with a measure of expected one-year-ahead year-on-year CPI inflation derived from consensus forecasts.

Table 1. Estimates of SGPMOD's NEER Reaction Function

Variables	***Domestic Factors Only***	***Domestic Factors + U.S. Fed Funds Rate***
Lagged Change in NEER	0.641***	0.624***
Expected Inflation	1.155***	1.202***
Output Gap	0.167***	0.178***
U.S. Fed Funds Rate	---	0.115*
Observations	96	96
R-Squared	0.7053	0.7058

Source: IMF staff estimates
Notes: *** significant at .01 level; **significant at .05 level; *significant at .10 level.
Estimation method: GMM regression, with four lags of output gap and inflation used as instruments

26. Preferred Specification. Our preferred specification uses a shadow measure of the U.S. Fed Funds rate (Wu and Xia, 2015). The reason for including it is that Singapore cannot set its own interest rates as it is too small to influence the interest rate implied UIP, especially since it has an

entirely open capital account. So, all else equal, a move in the U.S. interest rate moves the Singapore rate, which imparts extra volatility to the domestic economy. By including the U.S. interest rate in its determination of the target NEER, the MAS tries to spread the nominal-side adjustment into the NEER as well as Singaporean interest rates, thereby reducing volatility in their economy.

Singapore—Trend Equations

27. Defining Trends. We can derive the levels of variables such as real GDP and exchange rates once we specify the equations for their corresponding trends. The trends can then be paired up with their respective gap variables to compute their level equivalents.

28. Potential Output. The trend variable for real GDP is potential output, which can be thought as the unrealized, but possible, productive capacity of the economy:

$$\overline{Y}_t = \overline{Y}_{t-1} + ¼ g_t$$
$$g_t = \rho^g g_{t-1} + (1-\rho^g) g^{SS} + g_t^{shk}$$

where $\overline{Y}$ is potential output, and g is the potential growth rate of the economy, which normally grows at , but can deviate for long periods (for a value of ρ^g closer to 1) because of some exogenously specified shock, g^{shk}, which, conceptually, is usually related to productivity measures.

29. Level of Real GDP. When combined with the output gap to give the level of real GDP, we can also derive real GDP growth (quarter-on-quarter, annualized):

$$Y_t = \overline{Y}_t + y_t$$
$$\Delta Y_t = 4(Y_t - Y_{t-1})$$

30. Trend Exchange Rate. The trend real bilateral US$ rate of exchange depreciation is defined as:

$$\Delta\overline{Z}_t = \rho^{\overline{Z}} \Delta\overline{Z}_{t-1} + \left(1-\rho^{\overline{Z}}\right)[\Delta Z^{SS} + \rho^{g\overline{Z}}(g_t - g^{SS})] + \Delta\overline{Z}_t^{shk}$$

so that the level of the trend real bilateral US$ exchange rate can be derived from its rate of appreciation:

$$\overline{Z}_t = \overline{Z}_{t-1} + ¼ \Delta\overline{Z}_t$$

31. Balassa-Samuelson Effect. Note that if the trend growth rate, g, for potential output, $\overline{Y}$, increases relative to the baseline, the trend real exchange rate will appreciate permanently by amount $\rho^{g\overline{Z}}$. This is making the assumption that the increase in potential growth is being driven by productivity that is predominately in the tradables sector. A productivity shock that is economy wide or concentrated in nontradables should lead to a depreciation of the exchange rate. This is the Balassa-Samuelson effect.

Singapore—Exchange Rates and Other Equations

32. Bilateral US$ Exchange Rate. The real bilateral US$ exchange rate can be defined from the real bilateral US$ exchange rate gap and its trend, defined above:

$$Z_t = \overline{Z}_t + z_t$$

The nominal bilateral US$ exchange rate comes from identity linking consumer price levels and the real exchange rate:

$$S_t = Z_t + CPI_t - CPI_t^{US}$$

33. Defining Effective Exchange Rates. Using the equations for S and Z, along with other regions bilateral US$ exchange rates, we can define the NEER or REER, based on their shares of Singapore's imports from the rest of the world.

34. Defining the NEER. The NEER is defined as the weighted average of all foreign exchange rates against the SG$, using import trade weights. It is technically computed using bilateral US$ exchange rates and imputed cross exchange rates for Singapore, based on the seven regions as found in GPM (Blagrave and others, 2013). Here, we only consider the United States and China separately, and all the other regions are collapsed into a measure of the remaining countries (RW, which is the rest of the world excluding the United States and China).

$$NEER_t = imp^{US} S_t + imp^{CH}(S_t - S_t^{CH}) + (1 - imp^{US} - imp^{CH})(S_t - S_t^{RW})$$

35. Other Effective Exchange Rates. There are equivalent expressions for $\overline{NEER}$, $REER$, $\overline{REER}$,and $reer$. Conceptually, the identity linking the nominal and real effective exchange rates (where *ROW* is the rest-of-world including the United States and China) is:

$$NEER_t = REER_t + CPI_t - CPI_t^{ROW}$$

36. Other Definitions. There are also other definitions, such as the Fisher equation, to link the real and nominal interest rate with one-quarter-ahead expected inflation:

$$RS_t = RR_t + \pi_{t+1}$$

and price level equations based on inflation for domestic (core) CPI and rest-of-the-world CPI:

$$CPI_t = CPI_{t-1} + \pi_t$$
$$CPI_t^{ROW} = CPI_{t-1}^{ROW} + \pi_t^{ROW}$$

Rest of the World

37. Defining the rest of the world. The remainder of the model is referred to as the Rest of the World (ROW). It consists of the United States, China, and the other rest of the world countries (RW, which is euro area, Japan, emerging Asia and other economies), plus commodities (oil and food). Therefore, all ROW variables (such as the REER, the NEER, prices, and the output gap) are weighted

averages of variables related to the United States, China, the euro area, Japan, emerging Asia and other economies, whereas all RW variables (the REER, and the nominal and real bilateral US$ exchange rates) are import-weighted averages of only the euro area, Japan, emerging Asia and other economies.

38. Broad Features for ROW. So for the structure of the model, the United States and China have full blocks, similar to Singapore, derived from GPM-7 (Blagrave and others, 2013). Commodities (food and oil) are based on random walk stochastic processes for prices, which are often just used to replicate exogenously-specified paths based on the IMF's World Economic Outlook. Each of the other regions has a random walk stochastic process for their real bilateral US$ exchange rate gap and output gap. However, there are some extra links for emerging Asia, where China has direct impact on their output gap, and their real bilateral US$ exchange rate gap. These are important links to capture, since emerging Asia is Singapore's largest trading partner (approximately 45 percent of both their exports and imports). The remainder of this section looks at the United States and China blocks in greater detail, exploring in particular their monetary policy regimes, and their spillover channels onto Singapore.

The United States and China

39. Domestic Economy Blocks for the United States and China. As with Singapore, the United States and China blocks are both variants of the canonical gap models. As with Singapore they are based on aggregate demand (output gap) and Phillips' curve (aggregate supply) equations, which are not replicated here, due to their similarity. China also has a risk-adjusted UIP condition vis-à-vis the United States.

40. Monetary Policy Frameworks. Both countries have differing monetary policy rules. The United States follows an IT regime that uses an interest rate reaction function. China follows a managed floating exchange rate regime, with roles for both exchange rate and inflation targets. It therefore uses both interest rate and bilateral US$ exchange rate reaction functions.

Monetary Policy in the United States

41. U.S. Reaction Function. The United States follows an IT regime, so it has an inflation-forecast-based interest rate reaction function, using core inflation:

$$RS_t^{US} = g_1^{US} RS_{t-1}^{US} + (1 - g_1^{US}) * \left[\overline{RS}_t^{US} + \pi_{t+3}^{US} + g_2^{US}\left(\pi_{t+3}^{US} - \pi_t^{US,TAR}\right) + g_3^{US} y_t^{US}\right] + RS_t^{US,shk}$$

where RS^{US} is the U.S. nominal short-term interest rate; $\overline{RS}^{US}$ is the trend U.S. real short-term interest rate; $\pi_{t+3}^{US} - \pi_t^{US,TAR}$ is the U.S. expected core CPI inflation deviation from its target of 2.5 percent; and y^{US} is the U.S. output gap.

Monetary Policy in China

42. China's Monetary Policy. China's monetary policy regime is more complex. It is a dual instrument, dual target framework, fully explained in Blagrave and others (2013). It combines equations for:

- A nominal bilateral US$ exchange rate reaction function, which it is chosen by targeting China's output gap, and using a nominal bilateral US$ exchange rate target.
- An interest rate reaction function, which has the same specification as the interest rate reaction function in the United States.

Please note that this is not the BBC framework used by the MAS, which primarily pursues price stability. Instead it is a dual instrument, dual target system with China's nominal bilateral US$ exchange rate, S^{CH}, as a target in its own right.

43. Interest Rate Reaction Function. The components are as follows. First, there is the interest rate reaction function, to control core inflation:

$$RS_t^{CH,pol} = g_1^{CH} RS_{t-1}^{CH} + (1 - g_1^{CH}) * \left[\overline{RS}_t^{CH} + \pi_{t+3}^{CH} + g_2^{CH}\left(\pi_{t+3}^{CH} - \pi_t^{CH,TAR}\right) + g_3^{CH} y_t^{CH}\right] + RS_t^{CH,shk}$$

where $RS^{CH,pol}$ is China's policy setting for the nominal short-term interest rate; RS^{CH} is China's actual nominal short-term interest rate; $\overline{RS}^{CH}$ is China's trend real short-term interest rate; $\pi_{t+3}^{CH} - \pi_t^{CH,TAR}$ is China's expected core CPI inflation deviation from its implicit inflation target; and y^{CH} is China's output gap.

44. Exchange Rate Reaction Function. Second, there is China's nominal bilateral US$ exchange rate reaction function, which controls the level of their nominal bilateral US$ exchange rate, and works to smooth the path of the output gap:

$$S_t^{CH,pol} = S_{t-1}^{CH} + (\overline{Z}_{t+1}^{CH} - \overline{Z}_t^{CH}) + ¼\left(\pi_t^{CH,TAR} - \pi_t^{US,TAR}\right) - ¼ q_1^{CH} y_t^{CH} + S_t^{CH,pol,shk}$$

where S^{CH} is the China's actual nominal bilateral US$ exchange rate; $S^{CH,pol}$ is China's policy setting for the nominal bilateral US$ exchange rate; $(\overline{Z}_{t+1}^{CH} - \overline{Z}_t^{CH}) + ¼\left(\pi_t^{CH,TAR} - \pi_t^{US,TAR}\right)$ is the one-quarter-ahead change in China's target nominal bilateral US$ exchange rate; and y^{CH} is China's output gap.

45. Defining the Short-term Interest Rate and the Bilateral US$ Exchange Rate. Both reaction functions jointly determine the actual nominal short-term interest rate, RS^{CH}, and the actual nominal bilateral US$ exchange rate, S^{CH}, along with the values derived from the UIP condition for both variables. So RS^{CH} and S^{CH} are weighted averages using $r_1^{CH} = 0.80$ and $r_2^{CH} = 0.66$:

$$RS_t^{CH} = r_1^{CH} RS_t^{CH,pol} + (1 - r_1^{CH}) RS_t^{CH,uip}$$
$$S_t^{CH} = r_2^{CH} S_t^{CH,pol} + (1 - r_2^{CH}) S_t^{CH,uip}$$

United States' and China's Spillovers to Singapore

46. Direct U.S. Spillovers. The United States' economy acts directly on Singapore via the output gap, captured by the aggregate demand equation's two proxies for trade, the change in the REER, and the rest-of-the-world output gap. Singapore's core inflation is also affected directly by the REER, which is a proxy for imported goods prices. The UIP condition implies that the domestic Singapore short-term interest rates move one for one with the U.S. interest rate. The U.S. interest rate also has a small direct impact on the target NEER as set by the monetary policy rule.

47. Indirect U.S. Spillovers. The United States also an indirect impact on Singapore because of its direct impacts on China's UIP condition and China's output gap.

48. Direct China Spillovers. China has some of the same direct impacts on Singapore. It acts directly on Singapore, via the output gap, captured by the aggregate demand equation's two proxies for trade, the change in the REER, and the rest-of-the-world output gap. It also effects Singapore's inflation via its impact on the REER.

49. Indirect China Spillovers. Its indirect impacts on Singapore can come through its effects on the United States via its output gap, and more importantly, its direct impacts on emerging Asia, as outlined in the introduction to this subsection.

C. The Behavior of Monetary Policy in SGPMOD

50. Understanding Monetary Policy in SGPMOD. In order to better understand how SGPMOD behaves in more complex scenarios, we should first examine the responses of the model in face of simple shocks to the economy. In this case, we are going to look a shock to domestic demand in Singapore. This will allow us to understand better the behavior of monetary policy. Moreover, in order to comprehend the MAS' BBC framework, we will consider two versions of it, alongside a framework based on the use of the short-term interest rate as an instrument.

51. Three Reaction Functions. In order to elucidate the properties of SGPMOD under Singapore's unique NEER reaction function, we will consider three different versions of the model, with variant monetary policy reaction functions. However, all three are compatible with an IT framework. In the three reaction functions, there are up to four different parameters. They are:

- g_1 = Inertia in the policy instrument.
- g_2 = the expected 3-quarter-ahead deviation of inflation from its target. The three-quarter length reflects the speed of transmission of the policy instrument (either the interest rate or the NEER) to inflation through domestic demand.
- g_3 = the contemporaneous output gap.
- g_4 = the U.S. interest rate gap (included only in the third reaction function).

The three policy rules are then calibrated as follows.

52. **Rule 1** is an interest rate reaction function. The policy instrument is the short-term interest rate (RS), such that:

$$RS = f(\text{lagged } RS, \text{inflation gap, output gap})$$

The coefficients, as defined above, are g_1= 0.65; g_2 = 1.70; g_3 = 0.20.

53. **Rule 2** is a NEER reaction function. The policy instrument is in the NEER from the previous quarter, such that:

$$\Delta NEER = f(\text{lagged } \Delta NEER, \text{inflation gap, output gap})$$

The coefficients, as defined above, are g_1 = 0.65; g_2 = 1.70; g_3 = 0.20. The actual NEER may deviate from reaction function, but the MAS will eventually undo, or adjust its policy to account for this, such that:

$$NEER = MAS'\ NEER + (\text{usually}) \text{ transitory variation}$$

54. **Rule 3** is also a NEER reaction function. It shares the same instrument as **Rule 2,** but with an additional weight on the U.S. interest rate (RS^{US}). The coefficients, as defined above, are g_1 = 0.65; g_2= 1.10; g_3 = 0.15; g_4 = 0.11.

55. **Justification for Rule 3.** Singapore cannot actually set its own interest rates, as they are too small to influence the interest rate implied by uncovered interest rate parity, especially since they have an entirely open capital account. So, all else being equal, a move in the nominal short-term U.S. interest rate moves the Singapore rate, which imparts extra volatility to the domestic economy. By including the U.S. interest rate in its determination of the target NEER, the MAS tries to spread the nominal-side adjustment into the NEER as well as the Singaporean interest rates, thereby somewhat reducing volatility in inflation and output.

The BBC Framework and the Policy Rules

56. **Preferred Reaction Function.** We conclude from the econometric estimation presented above, the announced MAS policies, and the results below for a temporary fall in domestic demand, that **Rule 3** is the best representation for BBC framework. It is consistent with the basket and the band being rarely adjusted. This is also true for the adjustment of the rate of crawl, which is infrequent (often 6 months to a year apart). The rate of adjustment seems more related to the perception of the REER than the MAS' core CPI inflation measure, which has run at 2 percent year-on-year, or lower, with few exceptions (primarily 2009 and 2010) since the Asian Financial Crisis.

57. **The Appreciation of the REER.** We should also note that it is likely that the ongoing appreciation of the REER is slowing. First, the productivity growth gap with its main trading partners seems to be narrowing (as there is higher trend growth in the rest of emerging Asia). Second, potential output growth seems to be slowing because of lower domestic productivity growth and the onset of the demographic shift already seen in Japan and Korea (IMF, 2015).

58. Additional Assumptions for the Policy Framework. At this point we should point out the behavior of monetary policy in SGPMOD depends on two strong assumptions, which, admittedly, seem to hold. First we assume that Singapore can always intervene to defend its target NEER and sustain the use of its reaction function. It appears to be successful for the most part, but there have been some instances that may be a failure of this assumption, such as the large downward re-centering in 2005, and the surprise "off-cycle" move of monetary policy in January, 2015. Second, since Singapore has a fully open capital account, there is no role for capital controls in monetary policy. Therefore, NEER targeting may be harder to achieve than in countries with such controls. They must rely solely on market intervention, whether it is from the use of the BBC framework, verbal intervention or actual intervention in foreign exchange markets in the short term. However, such circumstances may be part of the reason Singapore runs large current account surplus—it allows for accumulation of a large financial buffer and currency reserves that can be used in challenging times. Therefore, SGPMOD works under the assumption that these buffers and reserves are always sufficient to cover the MAS' monetary policy choices, and do not need to be explicitly modeled.

The Monetary Policy Transmission Mechanism—A Fall in Domestic Demand

59. Introduction. Recall that the MAS is trying to achieve price stability, with an eye to reducing output volatility. In order to do so, they use a monetary policy reaction based on the NEER. For the sake of comparison below, we will also consider a case where the MAS uses an interest rate reaction function instead, simply as a didactic exercise, to contrast the different behavior. The transmission mechanism described below is that found above in Figure 2. In order to illustrate it, we will consider what happens when there is a surfeit of domestic demand in the economy, such that the output gap becomes negative, and there is excess demand.

60. Behavior of the Mechanism. Regardless of the form of the policy rule, because the MAS follows an IT regime, a decrease in domestic demand follows the same behavior:

- The output gap enters excess supply, which leads to disinflation, which elicits a monetary policy response;
- Monetary policy takes an expansionary stance, which encourages aggregate demand, putting upward pressure on the output gap;
- As the output gap becomes more positive, inflationary pressures increase, and inflation begins to return to its target level;
- As the inflation gap closes, the MAS withdraws its stimulus; and
- Finally, inflation returns to target and the output gap closes.

61. Different Behavior under Different Reaction Functions. However, there are distinctions between the actual behavior of monetary policy, whether the MAS implements its IT regime using an interest rate reaction function, or a NEER reaction function. The detailed explanation below

outlines the mechanics under the NEER reaction function, and then provides a contrast to the use of the interest rate reaction (Figures 3 and 4).

62. How the Mechanism Works on Impact. Upon the impact of such a shock, the MAS depreciates the NEER immediately. Because inflation is sticky, the REER will also depreciate on impact. This leads to higher net trade—exports rise as their goods cost less abroad, while imports fall as their cost to Singaporeans rise, especially since exchange rate pass-through is relatively fast in an open economy such as Singapore. However, the pass-through to import prices is still not enough to overturn the link between the NEER and the REER. Higher trade means that the output gap will begin to close, and the excess demand will decrease. Both this, and the depreciated REER, adds inflationary pressures to the economy, and MAS core inflation begins to rise.

63. Role of UIP in the Near Term. The MAS' depreciation of the NEER also works through the UIP condition. The nominal bilateral US$ exchange rate depreciates in line with NEER, and Singapore's short-term interest rate increases relative to that of the United States:

$$\uparrow RS_t = RS_t^{US} + PREM_t - \downarrow \Delta S_{t+1} \Rightarrow \uparrow RR_t$$

Since inflation is somewhat sticky, the real interest rate, *RR*, will also increase. The increase in the real interest rate works against the depreciation of the REER in the determination of Singapore's output gap. Therefore, without a complete understanding of the weights of those variables in the behavior of the output gap, the effects of monetary policy may be ambiguous on impact.

64. Contrast with an Interest Rate Reaction Function in the Near Term. In a country using an interest rate reaction function instead, the nominal short-term interest rate would fall, as would the real, while the exchange rate would depreciate, meaning that the two instruments would both work in the same direction. Therefore, since Singapore uses a NEER reaction function where the two instruments (the NEER and the short-term interest rate) work at cross purposes, it experiences more volatility than a country under an interest rate reaction function, even if both countries are IT regimes.

65. How the Mechanism Works in the Medium Term. After the first year, it becomes clear that the REER is only changing temporarily. This also a logical outcome, since the shock itself is only a temporary phenomenon, plus economic fundamentals are unaffected by monetary policy in the medium to long term. Therefore, the REER will start to appreciate towards it long-term value, as will Singapore's real bilateral US$ exchange rate. As the real bilateral US$ exchange rate appreciates, so will the nominal, despite rising inflation, because inflation is still rising more slowly than the rate of appreciation, because of price stickiness. Therefore, the UIP condition means that Singapore's short-term interest rate will fall relative to that of the United States:

$$\downarrow RS_t = RS_t^{US} + PREM_t - \uparrow \Delta S_{t+1} \Rightarrow \downarrow RR_t$$

In the medium term, monetary policy is now stimulative. Although the change in the NEER (and therefore the US$ bilateral rate) removes the stimulus from the economy, the real interest rate works

to reintroduce it. The real interest rate offsets the MAS' stimulus in the short term, but slows slowing its withdrawal in the medium term. The REER effect still predominates, because the highly open nature of Singapore's economy.

66. Contrasted with an Interest Rate Reaction Function. The NEER reaction function faces challenges from the opposition of the short-term interest rate and the REER, as explained above. An interest rate reaction function does not face such challenges. Both the REER and the real short-term interest rate adjust quickly (Figure 3). Under the NEER reaction function, the REER is constrained by the NEER rule, and the real short-term interest rate is contractionary in the first quarter before becoming expansionary. By contrast, the interest-rate reaction function returns inflation and output to its baseline, but with less volatility and more quickly. This is a recurrent theme when comparing the behavior of the two reaction functions for any shock.

67. Using the Reaction Functions for Singapore in Practice. But the apparent superiority of the interest rate reaction function in delivering lower volatility and faster adjustment in SGPMOD is very unlikely to hold, in practice. An interest rate reaction function for Singapore is a poor choice. As a small, very open economy, with an entirely open capital account, and a strong role as a regional financial center, Singaporean interest rates are mostly influenced through its financial markets, which can best be proxied in SGPMOD by the UIP condition.

D. Downside Risks to Singapore

68. The Risks under Consideration. As the current economic environment unfolds, there are a number of risks to the Singapore economy, which at this juncture, are skewed to the downside. They are basically complex combinations of the model properties presented above, with differing time horizons and variable magnitudes. While we can often untangle the sources of the shocks, it is difficult to determine how they interact with one another in the Singaporean economy, without the use of a tool such as SGPMOD. We consider four scenarios—a sudden downward revision in expected potential output growth in Singapore; a sudden downward revision in expected potential output growth in China; another version of the China scenario, but leading to additional turmoil in other emerging markets; and the effects of Brexit.

69. Presentation of the Risks. We assume that the risk starts to unfold in 2016Q2 (2016Q3 in the case of the Brexit scenario). The outcomes are presented relative to a baseline forecast to the end of 2018Q4. We recognize that the MAS may not be able to offset the effects exclusively. For example, fiscal policy and other structural policy can also play a role. However, we are only interested here in examining the role monetary policy can play in modifying the short-term dynamics of the economy. We consider two cases to describe the new target NEER relative to its baseline path: first, there are ongoing policy adjustments to the target NEER; second; the MAS stays with the baseline target NEER path. In second case, the short-term interest rate remains unchanged because of its determination by uncovered interest parity.

70. Two Presentations of the Outcomes. When considering the adjustment of the NEER policy reaction function based on the estimated policy rule, we have two different presentations. For the

first, we allow the MAS to adjust the target NEER to move each quarter. The second is a stylized presentation of the MAS' BBC framework—a fixed movement in the rate of crawl lasting two quarters (six months), starting in either Q2 (April) or Q4 (October). For the second case we make an additional assumption, that the first move is made in 2016Q3—that is, in July, "off-cycle" for monetary policy, as the shock is large and unanticipated. Generally, the movement in the rate of crawl is some multiple of 0.25 percent. There are few substantive differences in the outcomes between the two presentations.

Lower Expected Potential Output Growth in Singapore

71. Defining the Scenario. Consider a scenario where Singapore's potential output growth is revised down, permanently, by one percent, quarter-on-quarter, at annual rates (Figures 5 to 7). The reported results are the outcomes on the economy, versus the original future expected path of real GDP in Singapore. We also assume that the fall in potential output growth leads to a decline in expected stock of wealth for households, which translates into an additional fall in Singapore output gap of roughly 0.25 percentage points (see, for example, the economy productivity shock for larger scale models such as GIMF in Anderson and others, 2013 or FSGM in Andrle and others, 2015). Moreover, there is constant upward pressure on Singapore inflation, because of the higher costs associated with the realization that potential capacity is not expanding as fast as originally expected.

72. Impact on Singapore. Because this is a permanent shock to the level of potential output, no matter what policy decisions the MAS makes, real GDP will decline in the medium to long term. All monetary policy can do is to mitigate the transition to the "new normal". But monetary policy is being pulled in two directions. First, there are inflationary pressures as aggregate supply is lower than expected, encouraging excess demand. However, the sudden revision in consumer wealth also encourages excess supply temporarily, as aggregate demand contracts. This drags down inflation.

73. MAS' Monetary Policy. It turns out the disinflationary demand-side impulses from the contraction are stronger. The MAS depreciates the target NEER. So relative to the case of unchanged monetary policy, it smooths volatility and slows the decline in output. If we formalize the policy moves made by the MAS using our representation of the MAS framework, we can see the outcomes are not significantly different (the solid blue lines in Figures 5 to 7, versus the dashed blue lines).

Lower Expected Potential Output Growth in China

74. Defining the Scenario in China. Consider a scenario where China's potential output growth is revised down, permanently, by one percent, quarter-on-quarter, at annual rates (Figure 8). The reported results are the outcome on the economy, versus the original future expected path of real GDP in China. We also assume that the fall in potential output growth leads to a decline in expected stock of wealth for households, which translates into an additional fall in China's output gap of roughly 0.25 percentage points. Moreover, there is constant upward pressure on China's inflation, because of the higher costs associated with the realization that potential capacity is not expanding as fast as originally expected.

75. Spillovers from China. There are direct impacts from China (Figures 9 to 11). First, the Singaporean output declines along with import demand from China. Moreover, since China is weakening, the renminbi yuan depreciates against all currencies, pushing up, in the short term, Singapore's NEER. Because prices are sticky, the REER appreciates as well. Of course, the lower output gap and REER appreciation are disinflationary.

76. Spillovers from Emerging Asia. The outcomes in China have indirect effects too, primarily through Emerging Asia. As Emerging Asia experiences a decline in its output (primarily from strong trade links with China), they reduce their imports from Singapore, which manifests itself as a lower Singaporean output gap.

77. Caveat about the Scenario. At this point, we should draw attention to the types of spillovers from China—they lead to neither a permanent decline in Singapore or emerging Asia potential growth, nor a crisis of confidence in ASEAN economies (with its attendant threat of capital flight). We will consider such extra effects on top of this "calmer" China scenario in the following scenario.

78. MAS' Monetary Policy. In this scenario, the MAS can definitely play a key role. Many of the short-term impacts are similar to those of the negative domestic demand shock. Monetary policy can smooth the transition to a lower long-term level of real GDP, but it cannot prevent it, as this scenario presents a permanent contraction in China's share in the global economy. If we formalize the policy moves made by the MAS using our representation of the MAS framework, we can see the outcomes are not significantly different (the solid blue lines in Figures 9 to 11, versus the dashed blue lines).

79. Conclusion. We can see the utility of the MAS' new target NEER path by comparing with the case where the MAS simply follows its baseline. We see that the NEER is too appreciated, and interest rates are too high, leading to notable negative consequences. The output decline is much larger, driven by the output gap, not potential output, thereby illustrating the importance of monetary policy, which can only act on the demand side of the economy. Inflation also turns out to be much weaker.

Lower Expected Potential Output Growth in China Leading to Emerging Market Turmoil

80. A Variant of the Previous Scenario. Now, reconsider the previous scenario about China's potential output growth rate. Since China is a key player in the global economy, it is not unlikely that there may be further effects based on investors' confidence in the economies most strongly linked to China, such as emerging Asia, and Singapore itself. Therefore, relative to the previous, "calmer" China scenario, this scenario amplifies its negative impacts with two additional assumptions about the riskiness of emerging Asian assets. First, there is a 1 percentage point increase in Singapore country risk premium in 2016, which declines to zero by 2017Q3. Second, there is additional country risk in emerging Asia, leading to additional depreciation in their real exchange rate gap vis-à-vis the United States.

81. Impact on Singapore. Singapore experiences additional negative impacts from the further falls in emerging Asia's output gap, and its real exchange rate gap (Figures 12 to 14). The additional increase in the Singaporean risk premium leads to a higher domestic short-term interest rate on impact, through the UIP condition. Passing through to the real short-term interest rate, it causes an even larger decline in real GDP, which in turn means inflation falls further than the "calmer" China scenario, in the short term. However, there is higher inflation in the medium term, and therefore greater relative cyclicality in Singaporean inflation.

82. MAS' Monetary Policy. Since future inflation is higher than in the "calmer" China scenario, the MAS does not need to move the target NEER as much—inflation stabilization is more important than output stabilization in its policy reaction function. In this case, the MAS is struggling to react properly, because of changes in the fundamentals of the exchange and interest rates outside of MAS' control. First, the trade weights of Singapore's trading partners permanently diverge from the composition in the official NEER basket, as Emerging Asia shrinks in size relative to everyone else. Second, the UIP condition is broken by the country risk premium shock, which means that the MAS' policy actions are no longer the sole determinant the short-term interest rate vis-à-vis that of the United States.

83. Conclusion. Overall, Singapore is much worse off in the presence of the additional emerging markets turmoil. Although it is clear that the MAS, even with the limitations it faces in using its NEER reaction function, as negotiations between the UK and the EU could potentially last more than a year. The economic scenarios that are considered here are illustrative only and do not suggest the eventual outcome of the negotiations.

The Effects of Brexit with Near-Term Global Turmoil

84. Background. The June 23, 2016, referendum in the UK on EU membership resulted in a majority that favored the UK leaving the EU. Brexit has a broad array of implications on the future relationships between the UK and the EU, both of a long-term and a short-term nature. Given their sizes in the global economy, the effects in those countries will be felt worldwide, and are being examined. We quantify the effects of Brexit on Singapore, based on a scenario similar to that used to develop the IMF's July WEO Update, starting in 2016Q3 (not 2016Q2, as in the previous scenarios). The scenario is concentrated in 2016 and 2017, as negotiations between the UK and the EU could potentially last more than a year. The scenarios considered here are illustrative only and do not suggest the eventual outcome of the negotiations.

85. Brexit and European Real GDP. There is a number of components focusing primarily in the UK and the EU, with additional effects added for the rest of the world. There is a medium-term contraction of trade between the UK and the EU, as the free trade links are reduced towards WTO standards. This leads to wider output gaps in the near term. Considerable uncertainty on the part of consumers and firms worsen this. By the end-2018, the EU output gap is 0.4 percent, and that of the UK translates into 0.45 percent for the remaining countries block (Figure 15).

86. Brexit and the European Financial Sector. The UK and EU financial sectors also sees tighter lending conditions, which increase in magnitude through 2017. The UK sector tightens more, as its role in mainland Europe is reduced because of exiting the EU. The peak effects are in 2017, as it takes time for markets to understand and react to the changes implied by Brexit. This is included in the EU and UK output gaps, and also weakens their bilateral US$ exchange rate gaps.

87. Global Implications. There are direct trade spillovers on China from lower foreign demand and their real GDP falls by 0.1 percent as end-2017, while U.S. real GDP troughs around 0.25 percent at end-2016. Therefore U.S. monetary policy is looser, and its short-term interest rate falls by about 1.1 percent by the start of 2018 relative to the baseline to combat the resulting disinflationary pressures from the direct negative spillovers from Europe and the safe-haven flows that appreciate the currency. The other regions see more negative impacts on their output gaps, falling at a steady pace, reaching -0.4 percent by end-2018.

88. Global Exchange Rate Patterns. Naturally, the regions at the epicenter (EU and UK) depreciate. The US dollar and Japanese yen both appreciate, as they are safe haven currencies. Note that this will be especially stimulative, all else being equal, for Singapore, adding to depreciation pressures on the Singapore dollar. China and the rest of emerging Asia depreciate, complicating the behavior of the Singapore dollar, and increasing upward pressure on the Singapore NEER.

89. General Outcomes in Singapore. We first consider the case where the MAS does not move the target NEER away from its baseline case. We can better discern the effects of the foreign shocks buffeting Singapore, without the mitigating impact of monetary policy (the red lines in Figures 16 to 18). Given the generally negative impact of the spillovers and financial market effects, the REER is depreciating in Singapore until the end of 2018, by about 0.9 percent (Figure 16).

90. Impact on Singapore. Real GDP contracts by more than 0.4 percent, led by reduced demand for Singapore's exports by emerging Asia, China, and the United States (in that order) until the end of 2018. The path of Singapore's REER generally works against this, driven by financial markets. Singapore's real bilateral exchange rates against the US dollar and the Japanese yen account for most the movement, with only a mild depreciation against emerging Asia. This is a by-product of the "safe-haven" financial flows to the United States plus Japan, to a lesser degree. Because the UIP condition drives the domestic financial market, the short-term domestic interest rate rises in 2016, and as U.S. monetary policy loosens in 2017, it retreats (Figure 17, left panels). The broad-based lower foreign demand and generally positive real interest rate is disinflationary, despite the depreciation of the REER (Figure 18).

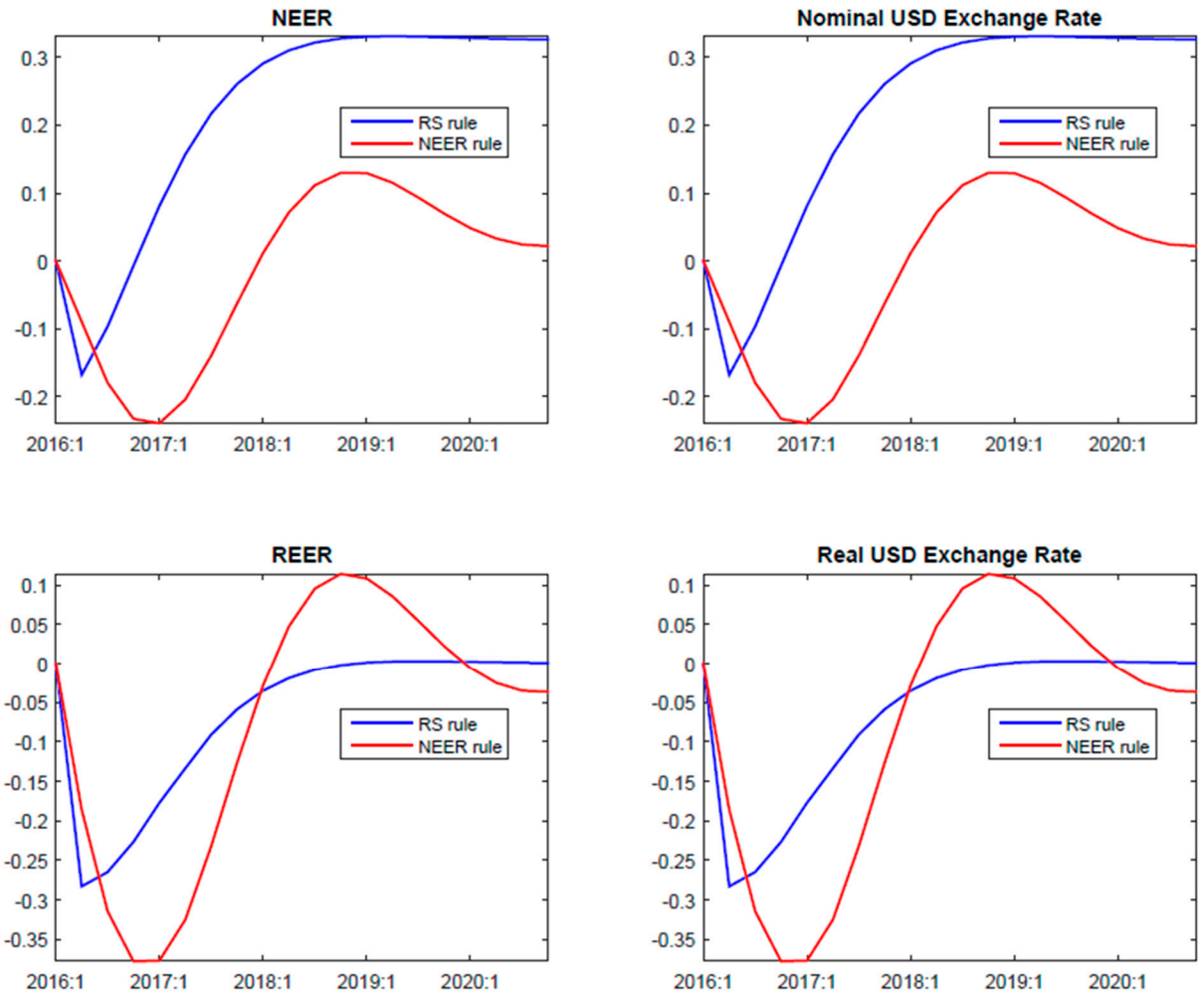
91. Additional Near-term Financial Risk. There is an increase in Singapore's country risk premium in the second half of 2016 of roughly 25 basis points – another reflection of safe haven effects on financial markets – that unwinds over the course of 2017. The negative interest rate effect is such that real GDP is 0.1 percentage points lower than it would be otherwise.

92. MAS' Monetary Policy. The baseline policy case demonstrates the need for the MAS to act. As expected they ease the target NEER. In the short-term, benefits from the depreciation of around

0.2 percent by end-2016 is offset by the almost 0.9 percent increase in the short-term real interest rate. However, the MAS continues to loosen over 2017 and into 2018, which markets anticipate, and the trough of real GDP is less long lived the baseline policy case – ending in 2017Q1 at 0.4 percent and quickly rising above zero by mid-2018, instead of lingering below 0.2 until end-2018. The generalized depreciation against the U.S. dollar across Singapore's major trading partners forces the MAS to rely on its bilateral U.S.$ exchange rate to achieve their target NEER. Therefore, the short-term interest rate is about 50 basis points higher than under the baseline policy case higher into 2018. However, by mid-2017 the NEER effect predominates over that of interest rates, with inflation recovering, as is real GDP. And because households and firms are forward-looking, inflation never falls as far as under the baseline case, reaching a trough of only -0.2 percent instead of -0.5 percent, in anticipation of MAS' defense of its inflation objective.

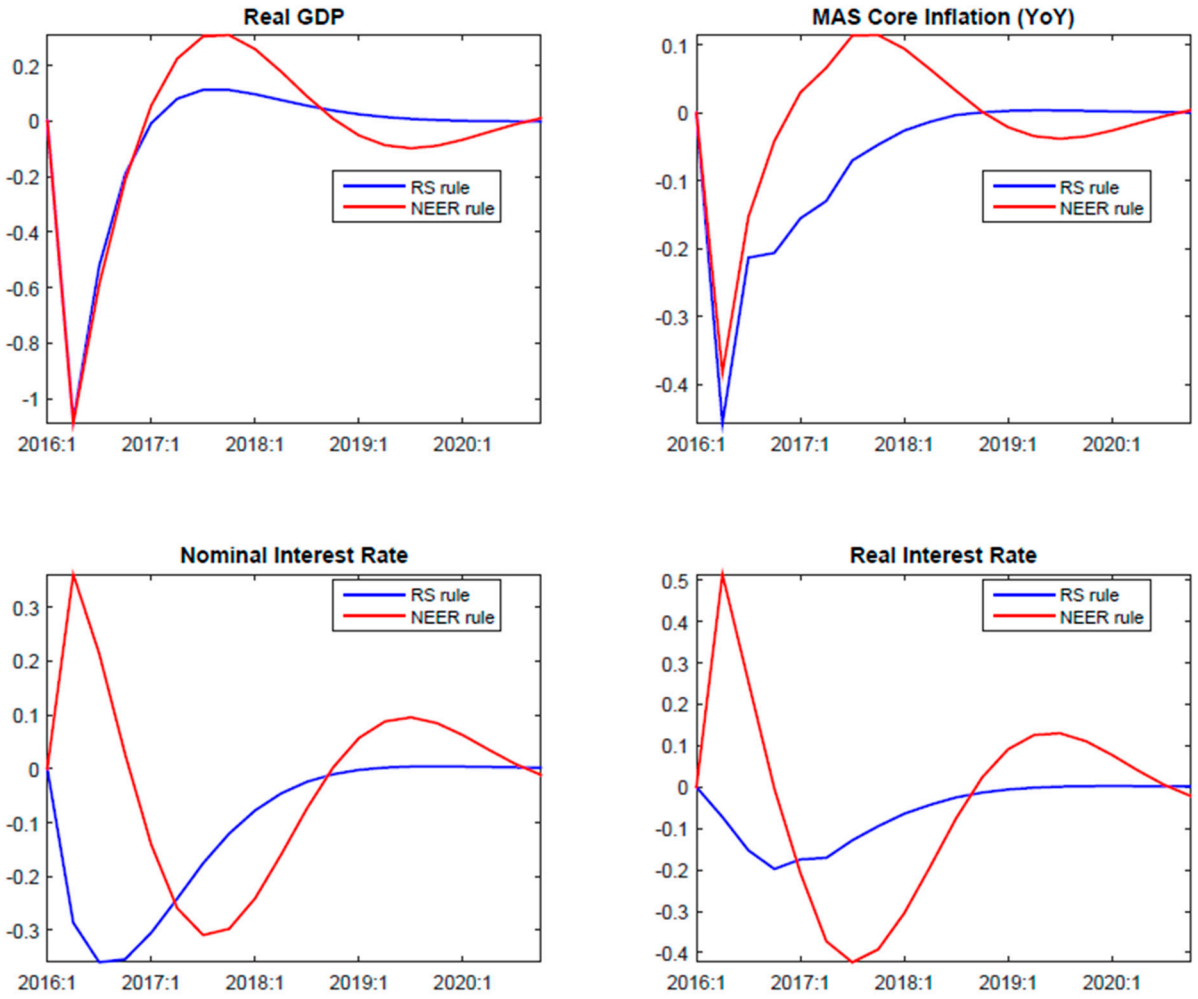
93. Conclusion. Monetary policy can do little to prevent the trough in real GDP in late 2016, but it can definitely contribute to a speedier recovery. In the near term, there is general global turbulence in exchange rate markets, exacerbating the negative effects from Singapore's transmission mechanism and its reliance on the UIP condition. Furthermore, there may be considerable short-term uncertainty from the hard-to-quantify safe-haven effects, which are very important for a financial center such as Singapore. Here, we have taken a relatively benign view. There could be further unexpected volatility, not explored here, starting in late 2017 or 2018, when the exit negotiations for the UK will presumably draw to a close.

Figure 3. A Decrease in Domestic Demand in Singapore—Singapore Exchange Rates
(Percent deviation from baseline)



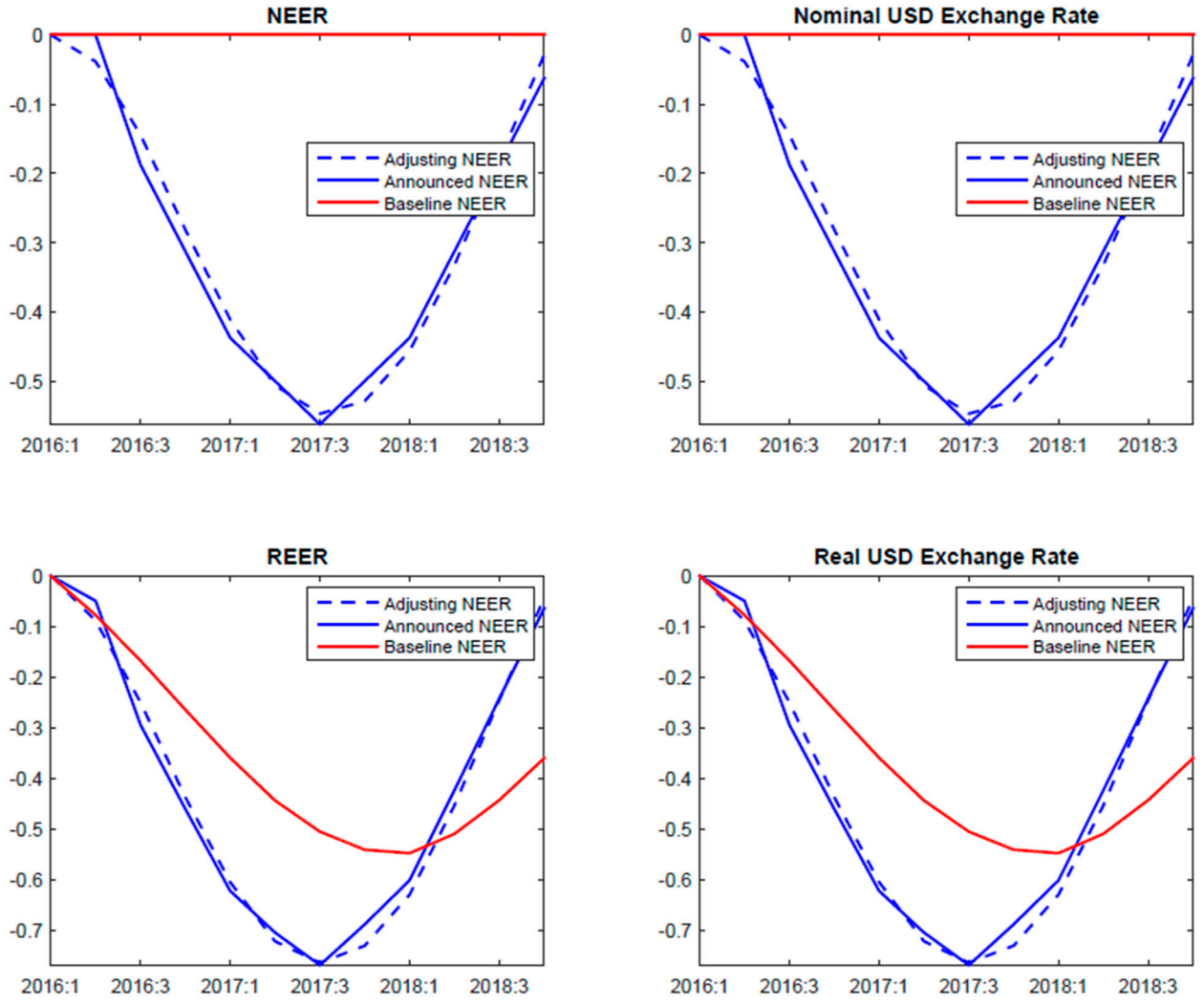
Source: IMF staff calculations.

Figure 4. A Decrease in Domestic Demand in Singapore—Singapore Economy
(Percent or percentage point deviation from baseline)



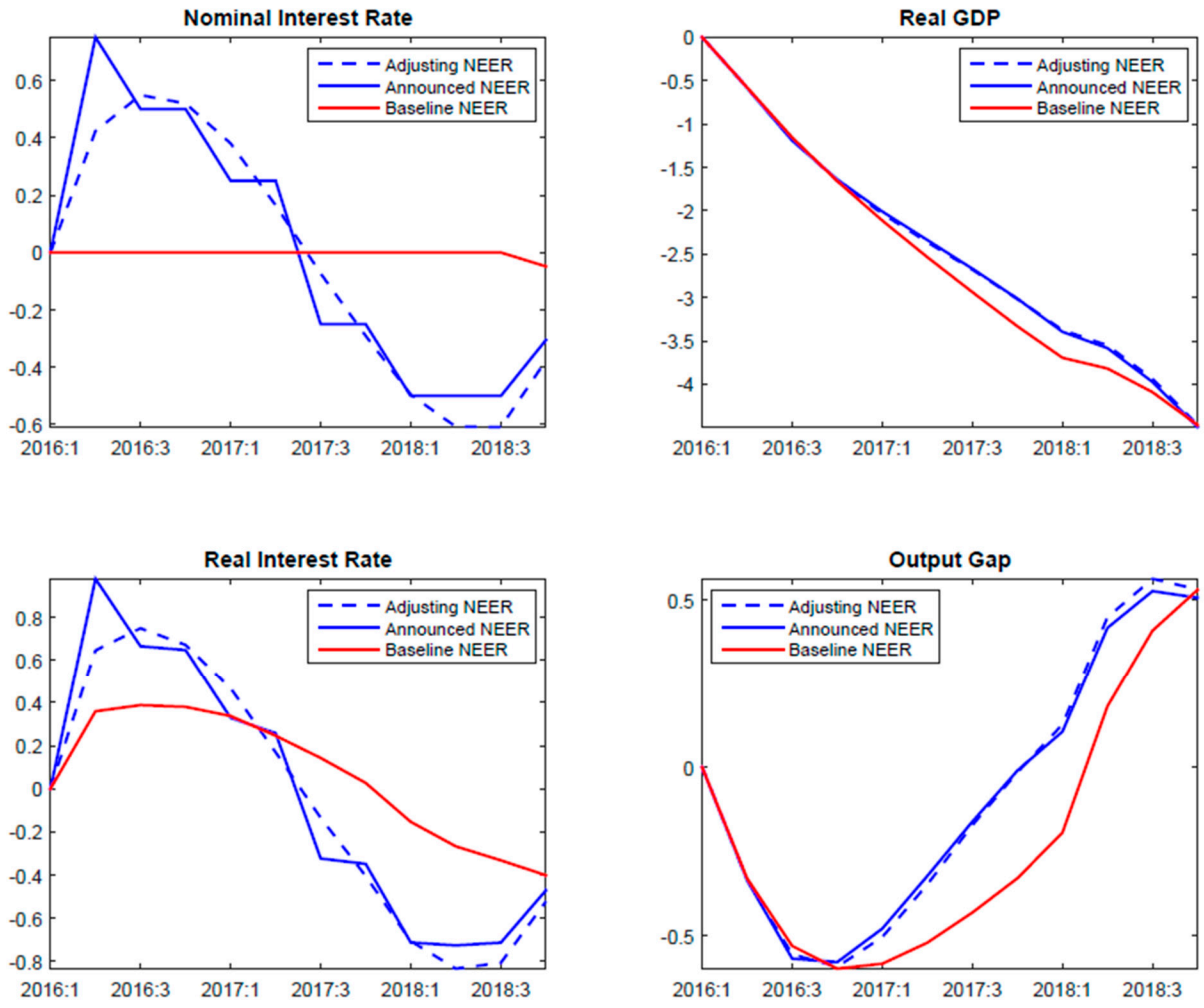
Source: IMF staff calculations.

Figure 5. Lower Expected Potential Output Growth in Singapore—Singapore Exchange Rates
(Percent deviation from baseline)



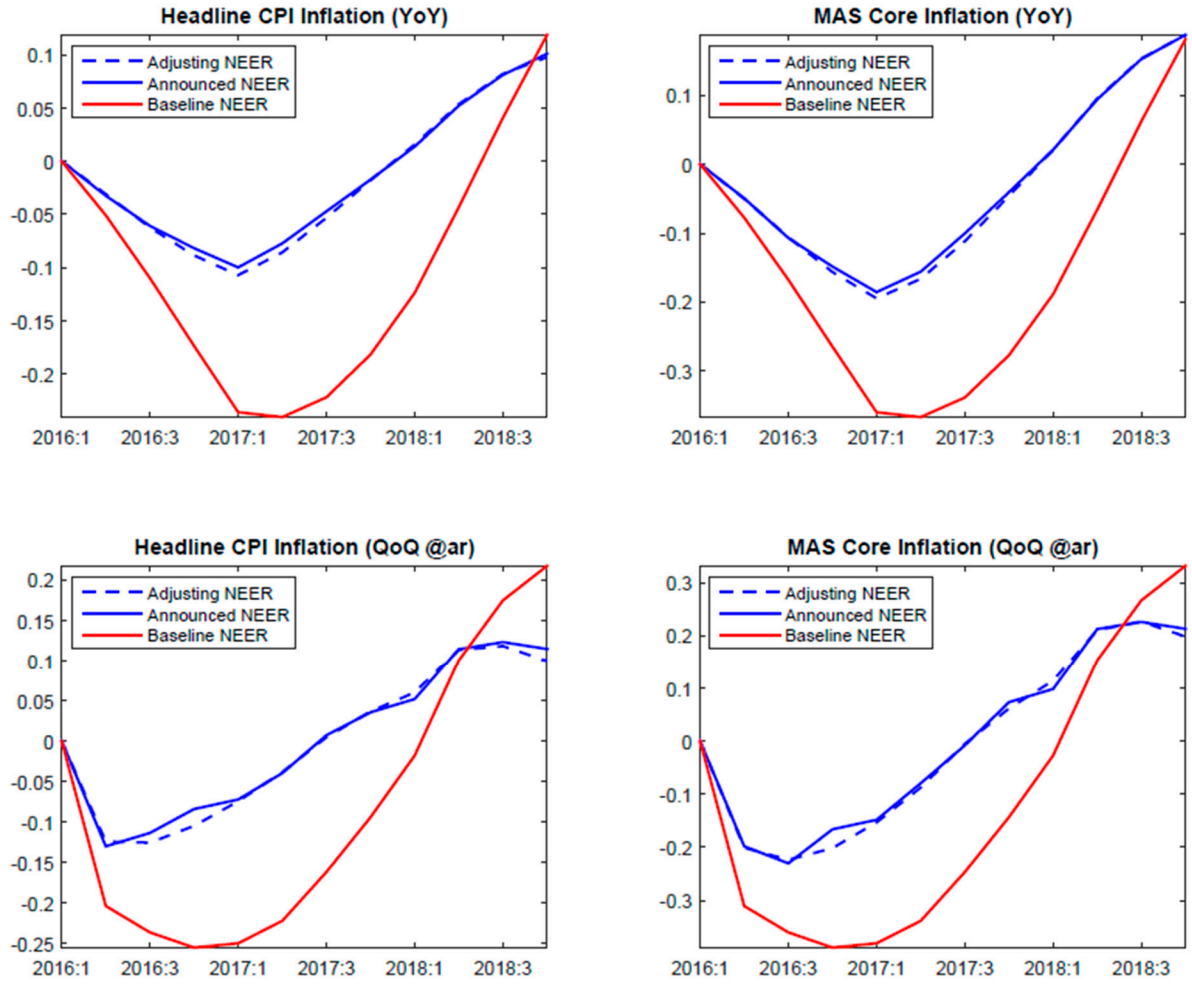
Source: IMF staff calculations.

Figure 6. Lower Expected Potential Output Growth in Singapore—Singapore Economy
(Percent or percentage point deviation from baseline)



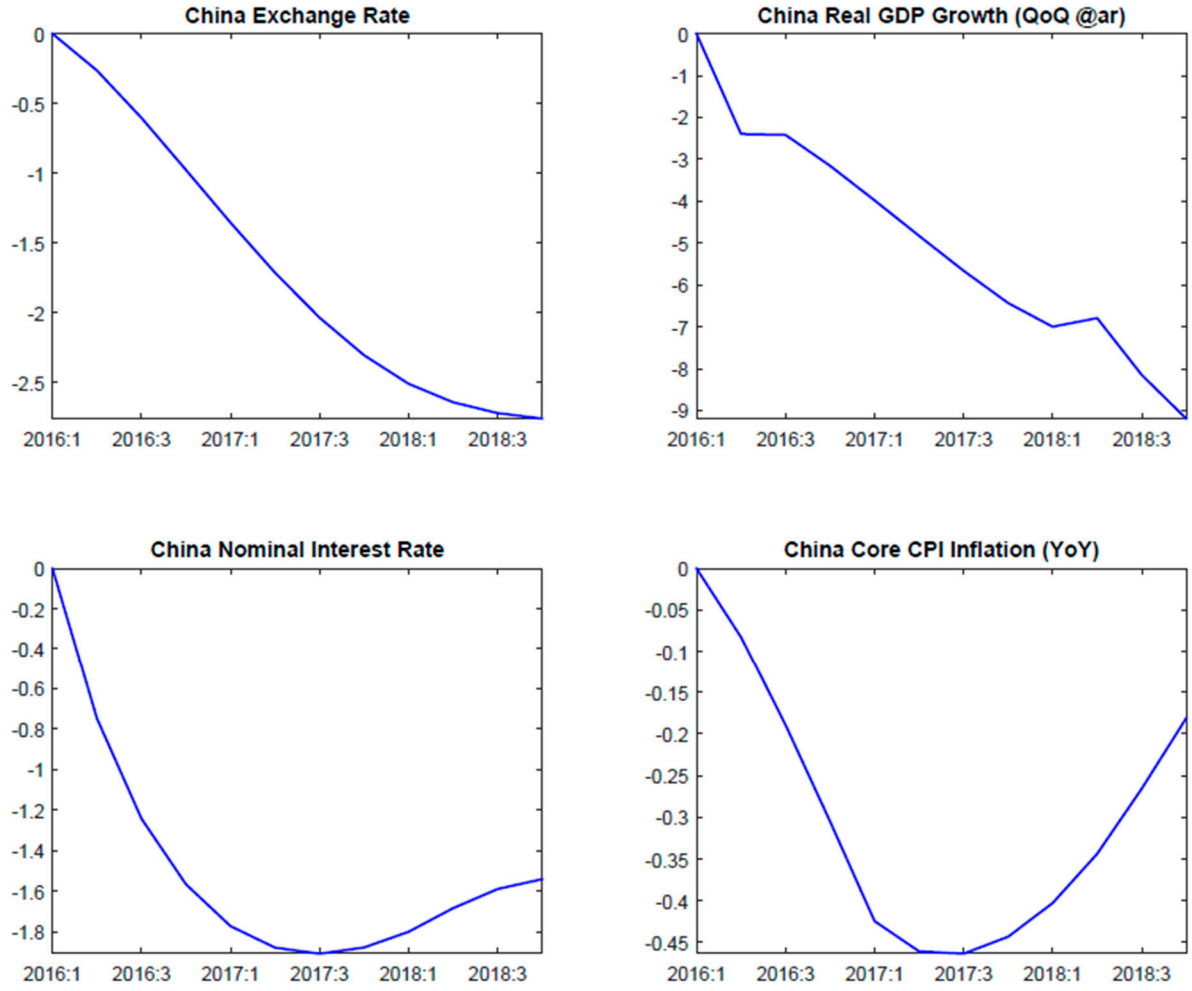
Source: IMF staff calculations.

Figure 7. Lower Expected Potential Output Growth in Singapore—Singapore Inflation
(Percentage point deviation from baseline)



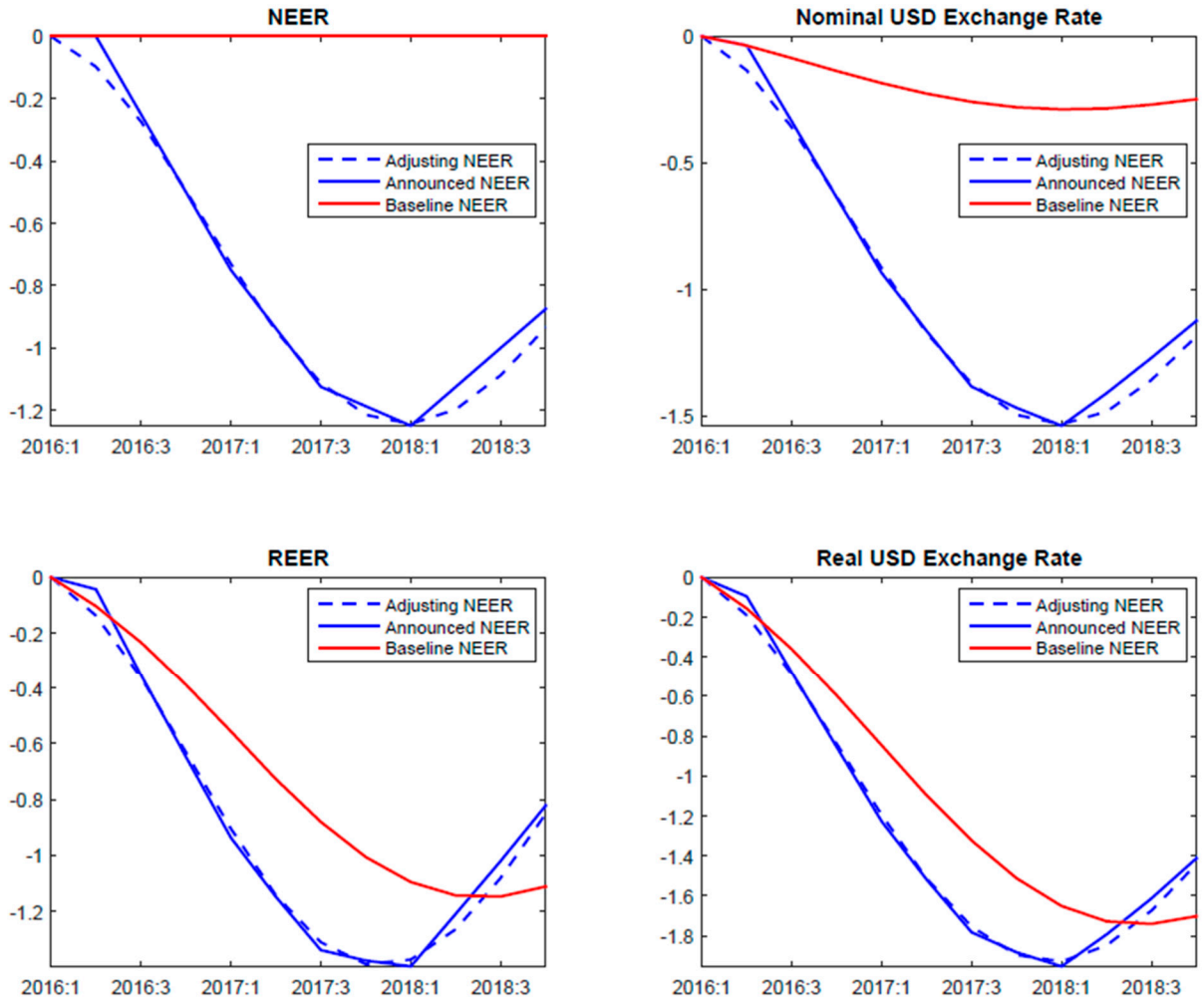
Source: IMF staff calculations.

Figure 8. Lower Expected Potential Output Growth in China—China
(Percent or percentage point deviation from baseline)



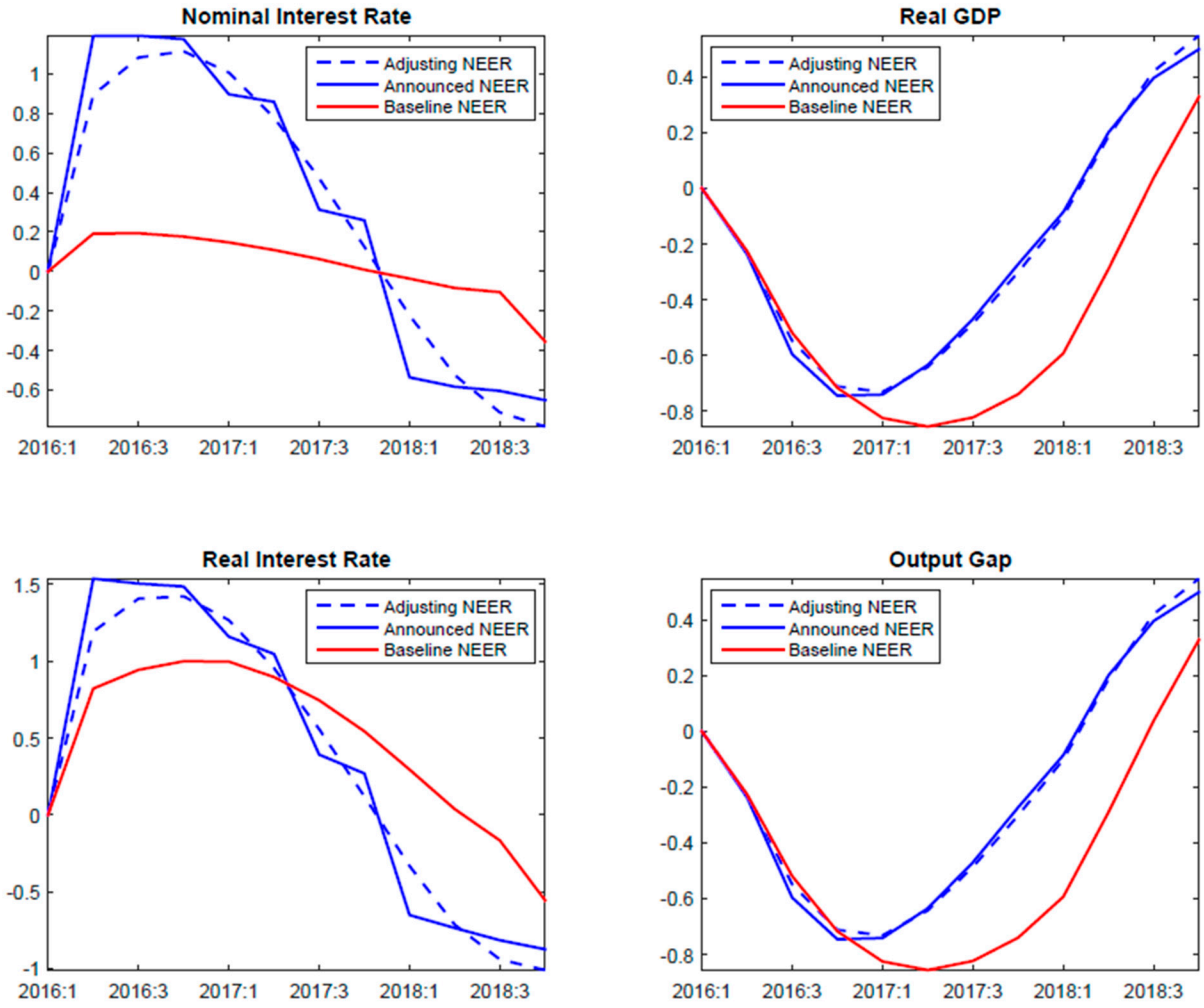
Source: IMF staff calculations.

Figure 9. Lower Expected Potential Output Growth in China—Singapore Exchange Rates
(Percent deviation from baseline)



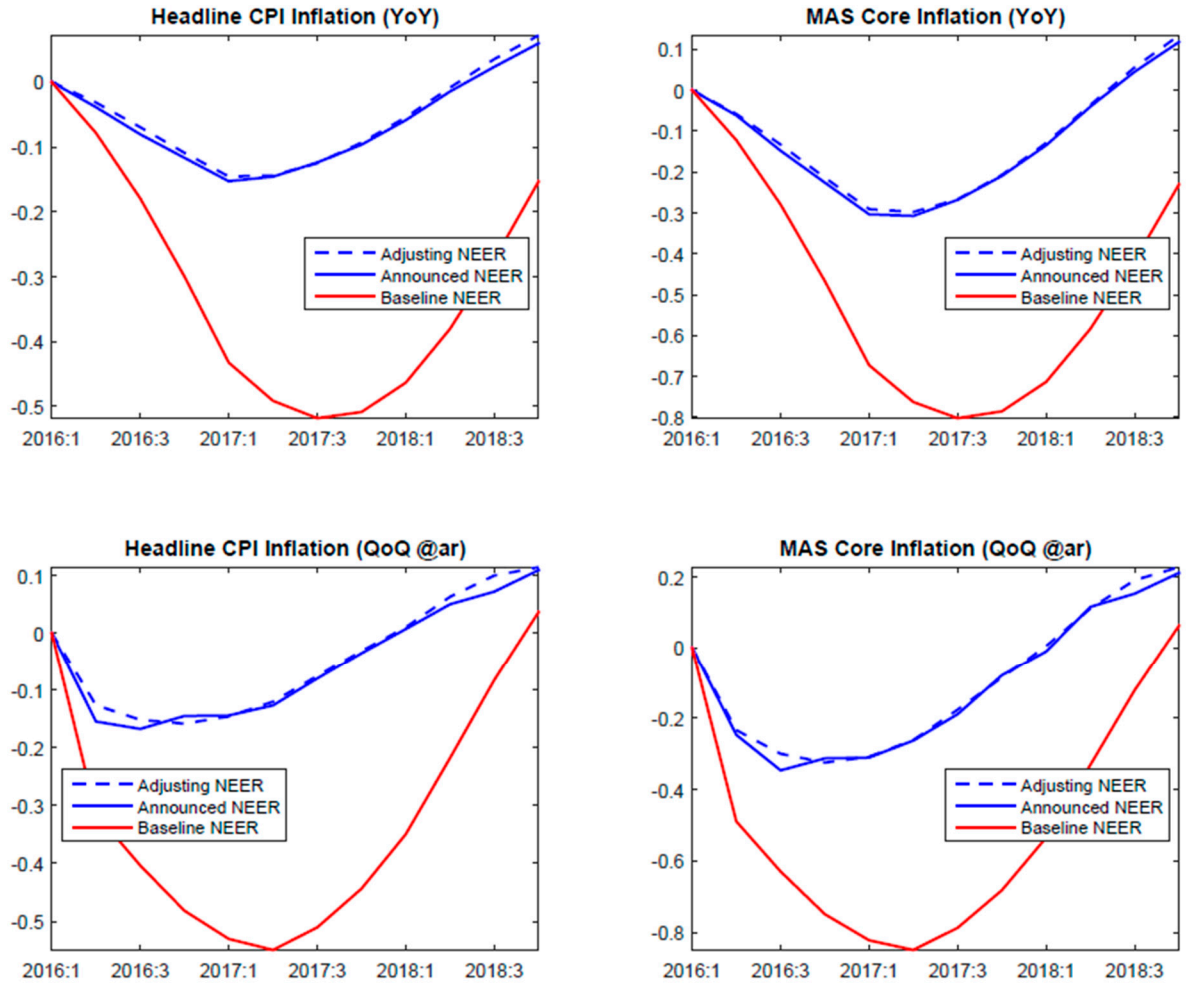
Source: IMF staff calculations.

Figure 10. Lower Expected Potential Output Growth in China—Singapore Economy
(Percent or percentage point deviation from baseline)



Source: IMF staff calculations.

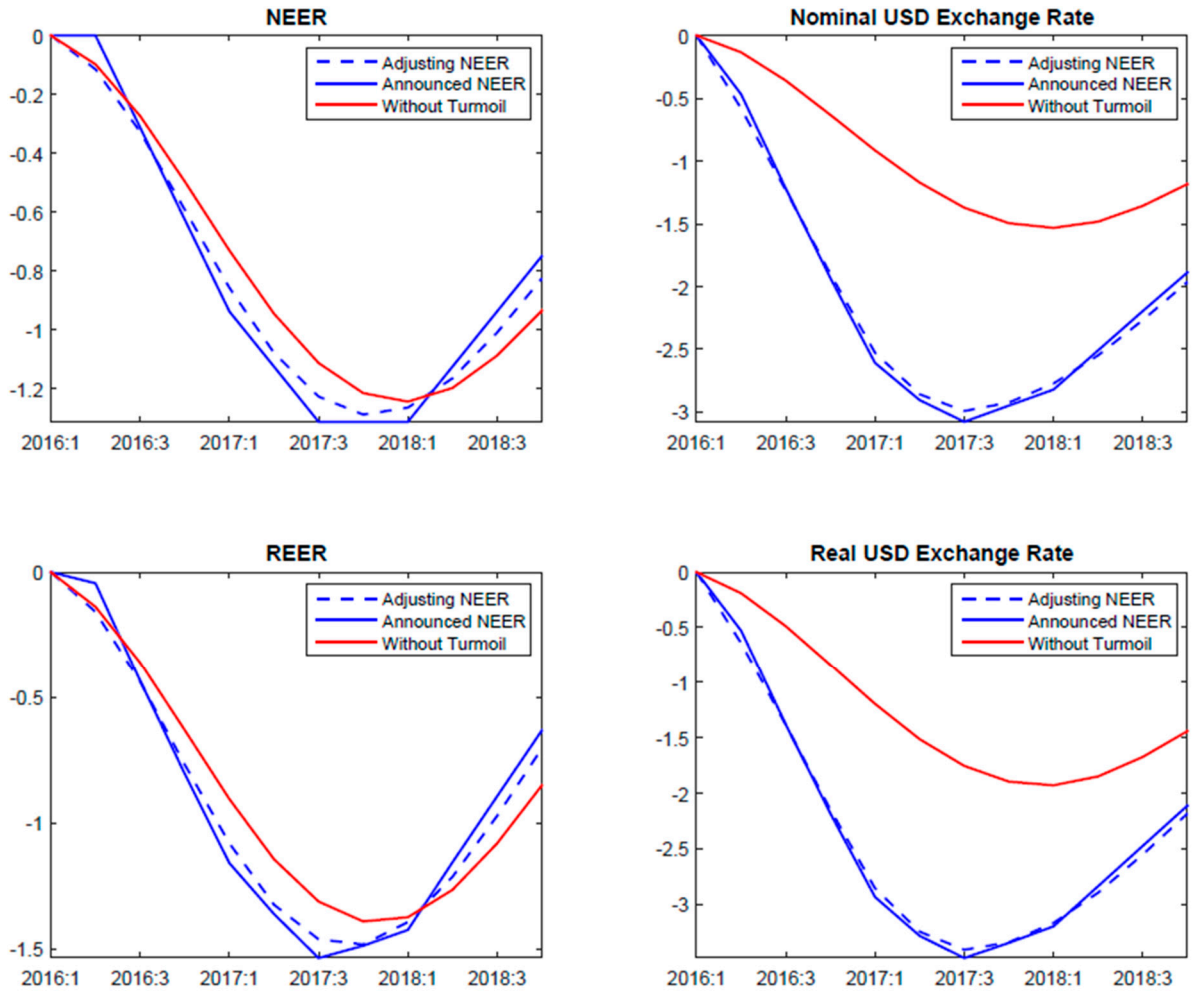
Figure 11. Lower Expected Potential Output Growth in China—Singapore Inflation
(Percentage point deviation from baseline)



Source: IMF staff calculations.

Figure 12. Lower Expected Potential Output Growth in China with Emerging Market Turmoil—Singapore Exchange Rates

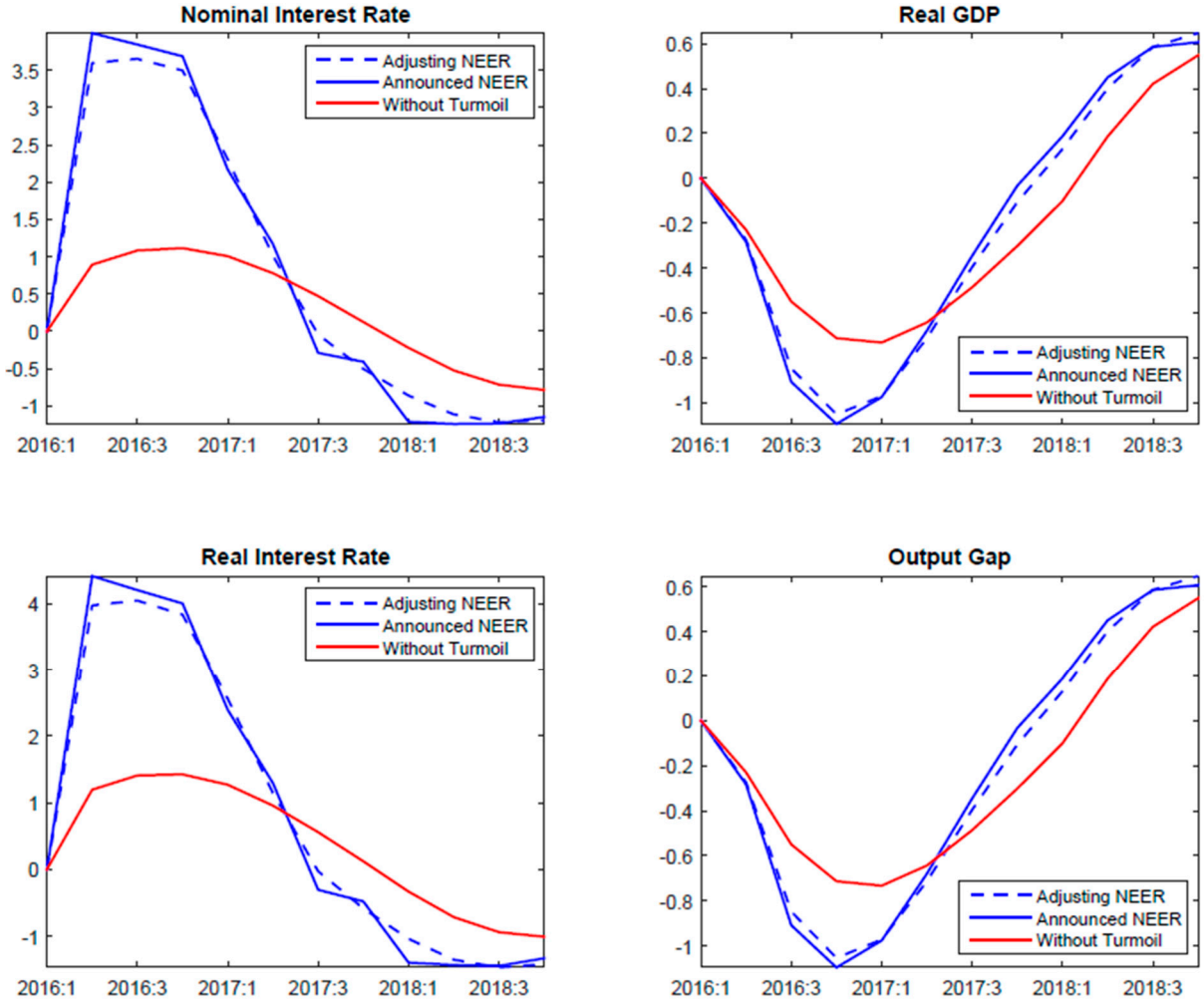
(Percent deviation from baseline)



Source: IMF staff calculations.

Figure 13. Lower Expected Potential Output Growth in China with Emerging Market Turmoil—Singapore Economy

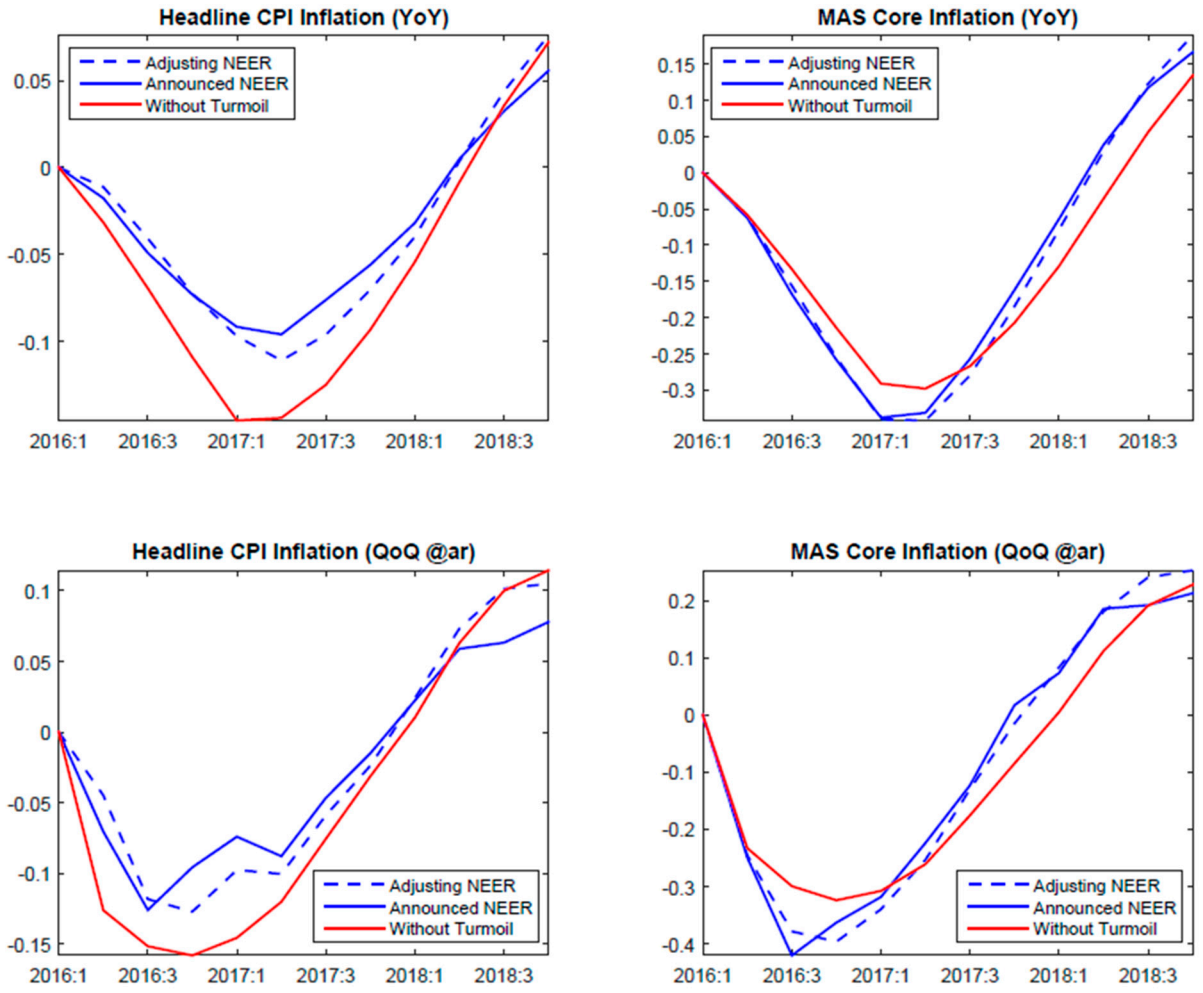
(Percent or percentage point deviation from baseline)



Source: IMF staff calculations.

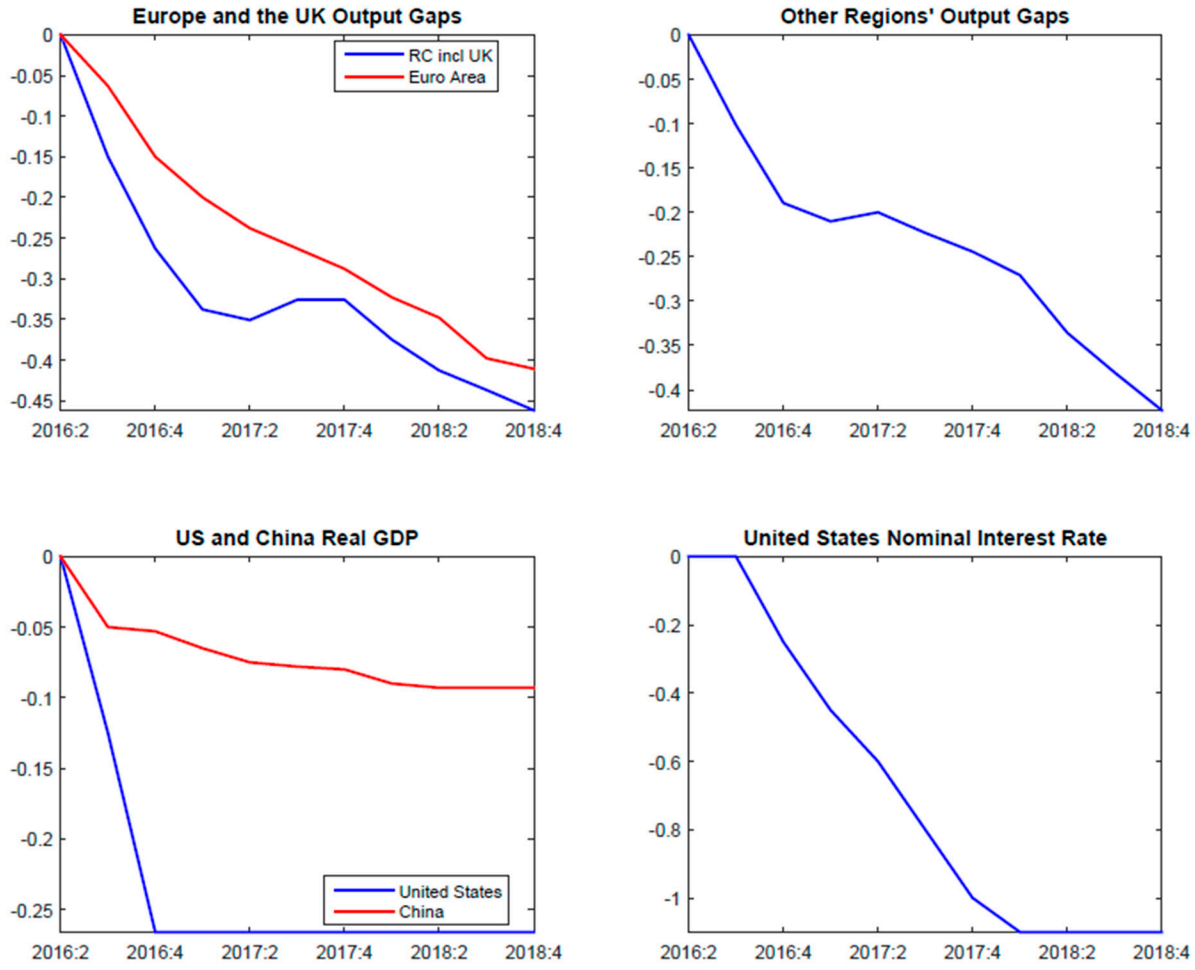
Figure 14. Lower Expected Potential Output Growth in China with Emerging Market Turmoil—Singapore Inflation

(Percentage point deviation from baseline)



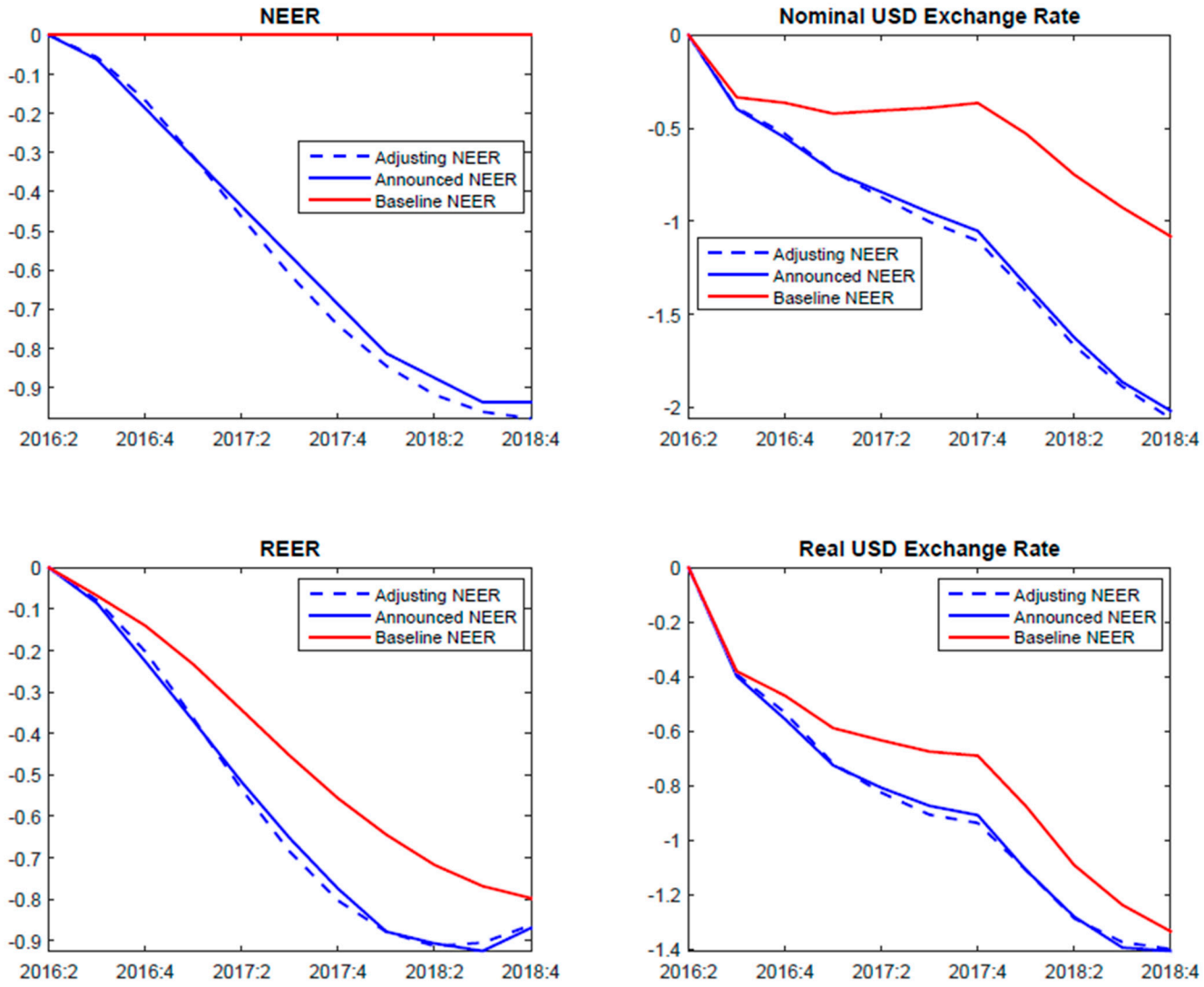
Source: IMF staff calculations.

Figure 15. The Effects of Brexit with Near-Term Global Turmoil—Rest of the World
(Percent or percentage point deviation from baseline)



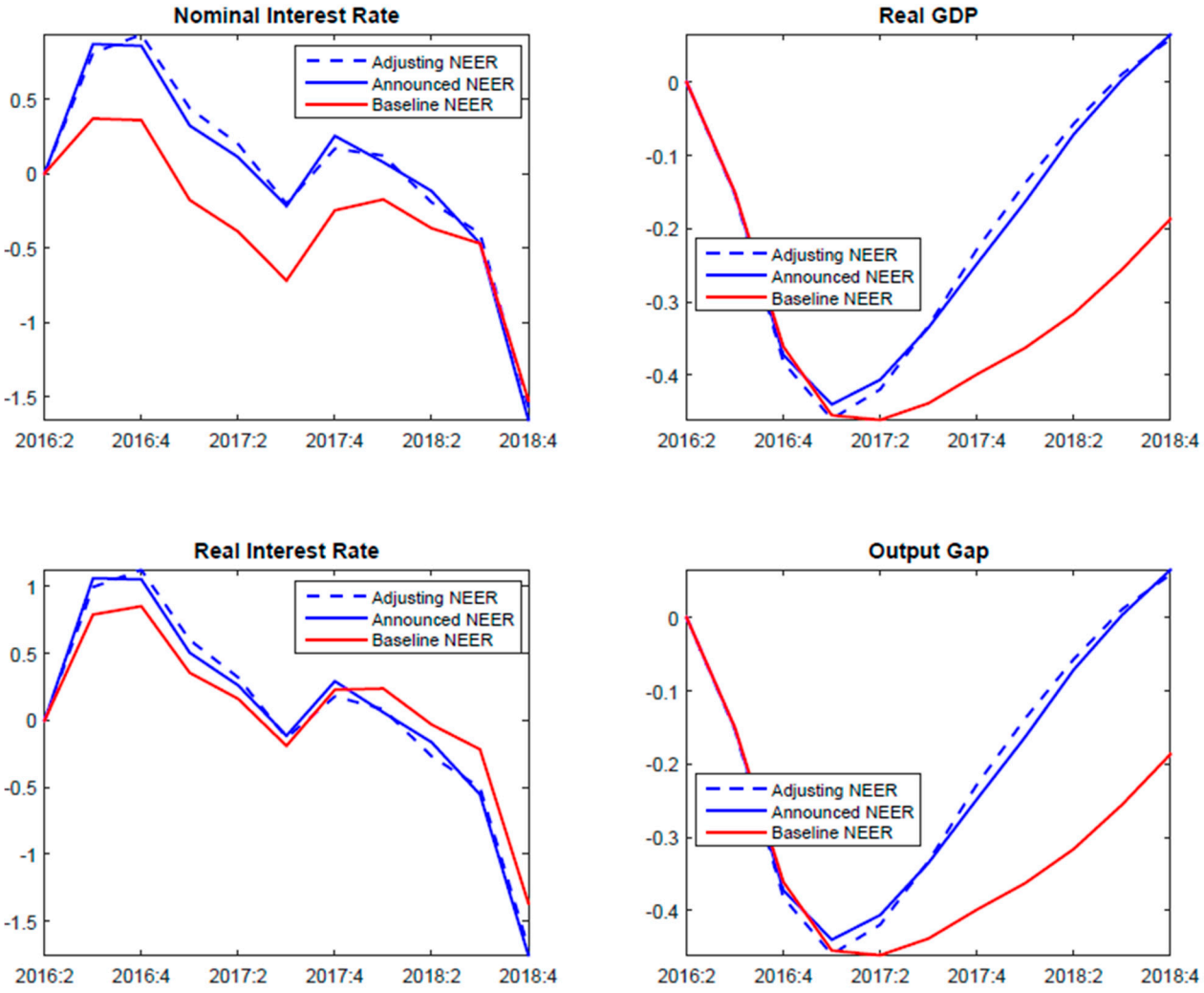
Source: IMF staff calculations.

Figure 16. The Effects of Brexit with Near-Term Global Turmoil—Singapore Exchange Rates
(Percent deviation from baseline)



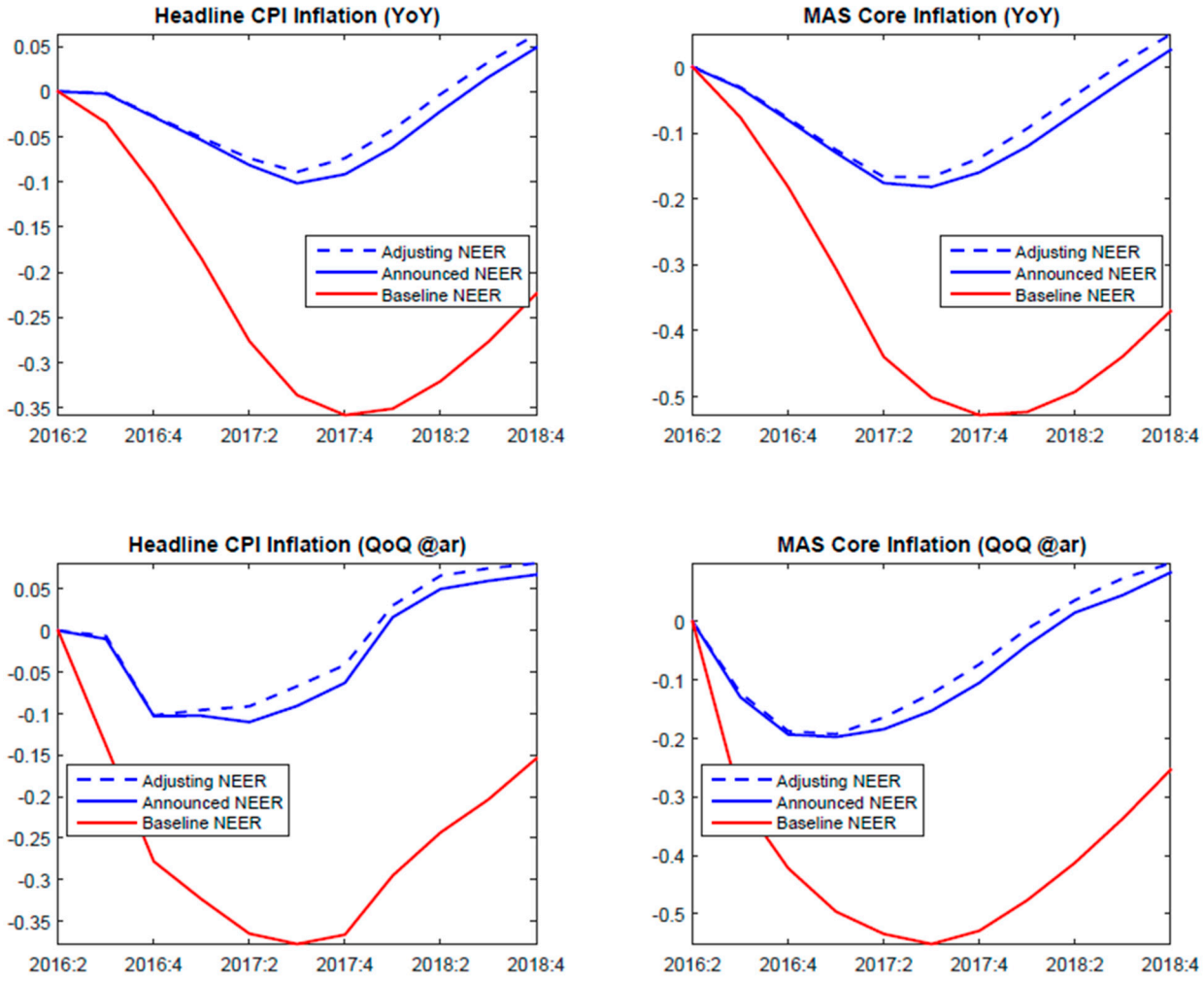
Source: IMF staff calculations.

Figure 17. The Effects of Brexit with Near-Term Global Turmoil—Singapore Economy
(Percent or percentage point deviation from baseline)



Source: IMF staff calculations.

Figure 18. The Effects of Brexit with Near-Term Global Turmoil—Singapore Inflation
(Percentage point deviation from baseline)



Source: IMF staff calculations.

References

Anderson, D., B. Hunt, M. Kortelainen, M. Kumhof, D. Laxton, D. Muir, S. Mursula, and S. Snudden. 2013, "Getting to Know GIMF: The Simulation Properties of the Global Integrated Monetary and Fiscal Model," International Monetary Fund, IMF Working Paper No. 13/55.

Andrle, M., P. Blagrave, P. Espaillat, K. Honjo, B. Hunt, M. Kortelainen, R. Lalonde, D. Laxton, E. Mavroeidi, D. Muir, S. Mursula, and S. Snudden, 2015, "The Flexible System of Global Models—FSGM," International Monetary Fund, IMF Working Paper 15/64.

Arbatli, E., 2015, "Appendix IV. Singapore—Estimating a Monetary Policy Rule for MAS," in *Singapore: 2015 Article IV Consultation—Staff Report*, International Monetary Fund, IMF Country Report No. 15/199.

Blagrave, P., P. Elliott, R. Garcia-Saltos, D. Hostland, D. Laxton, and F. Zhang, 2013, "Adding China to the Global Projection Model," International Monetary Fund, IMF Working Paper No. 13/256.

Carabenciov, I., C. Freedman, R. Garcia-Saltos, D. Laxton, O. Kamenik, and P. Manchev, 2013, "GPM6—The Global Projection Model with 6 Regions," International Monetary Fund, IMF Working Paper No. 13/87.

Gupta, S., "Appendix 3. Singapore: Potential Growth and Productivity" in *Singapore: 2016 Article IV Consultation—Staff Report*, International Monetary Fund, IMF Country Report No 16/263.

IMF, 2015, *Singapore: 2015 Article IV Consultation—Staff Report*, International Monetary Fund, IMF Country Report No. 15/199.

Khor, H., E. Robinson, and J. Lee, 2004, "Managed Floating and Intermediate Exchange Rate Systems: The Singapore Experience," Monetary Authority of Singapore, MAS Staff Paper No. 37.

MAS, 2001, *Singapore's Exchange Rate Policy*, Monetary Authority of Singapore, February, 2001.

MAS, 2013, *Monetary Policy Operations in Singapore*, Monetary and Domestic Markets Management Department, Monetary Authority of Singapore, March, 2013.

MAS, 2014, *The Satellite Model of Singapore (SMS): A Technical Overview*, Monetary Authority of Singapore, April, 2014.

MAS, 2016a, "Box C: A Model-Based Ex-Post Evaluation of Singapore's Monetary Policy" in *Macroeconomic Review*, Monetary Authority of Singapore, April, 2016.

MAS, 2016b, "Monetary Policy Statement" in *Macroeconomic Review*, Monetary Authority of Singapore, April, 2016.

McCallum, B., 2006, "Singapore's Exchange Rate-Centered Monetary Policy Regime and its Relevance for China," Monetary Authority of Singapore, MAS Staff Paper No. 43.

Parrado, E., 2004, "Singapore's Unique Monetary Policy: How Does It Work?" International Monetary Fund, IMF Working Paper No. 04/10.

Sheridan, N. and S. Nadeem, 2013, "Some Observations on Singapore's Monetary Policy Framework," in *Singapore: Selected Issues*, International Monetary Fund, IMF Country Report No. 13/327.

Wu, J. and F. Xia, 2015, "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound", University of Chicago—Booth School of Business, Chicago Booth Research Paper No. 13–77.

Zong Yao, D., C. Soo, C. Meng, and N. Eng, 2011, "A Review of the Core Inflation Measure for Singapore," Monetary Authority of Singapore, MAS Staff Paper No. 51.